Cutting Frequency Effects on Forage Yield and Stand Persistence of Orchardgrass and Alfalfa-Orchardgrass Fertilized with Dairy Slurry

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ABSTRACT : Previous research has not evaluated the effects of various rates and frequencies of manure application and frequencies of cutting on yield and stand persistence of cool-season grasses and alfalfa-grass mixtures. The primary objective of this study was to compare the effects of cutting management systems on herbage yield and stand persistence of orchardgrass (*Dactylis glomerata* L.) and an alfalfa (*Medicago sativa* L.)-orchardgrass mixture from various rates and frequencies of dairy slurry application. A randomized complete block design with treatments in a sub-subplot arrangement with four replicates was used. The main plot consisted of 2 cutting management systems (4 and 5 annual cuttings). The subplots were 9 fertility treatments: 7 slurry rate and frequency of application treatments, one inorganic fertilizer treatment, and an unfertilized control. The split-split-plots were the two forage species: orchardgrass and alfalfa-orchardgrass mixture. The study was initiated after 1st cutting in 1995. Cumulative yields of the 2nd and subsequent cuttings of both orchardgrass and alfalfa-orchardgrass in 1995 were higher for the 5-cutting system than the 4-cutting system. The 1995 growing season was abnormally dry. In 1996, an abnormally wet year, the reverse was true, total herbage yields being higher for the 4-cutting system than the 5-cutting system. Species response to fertility rate/frequency treatments was different in both years. Higher application rates early in the season and carryover of nutrients from late season applications the previous year appear to be responsible for the yield increases of those fertility treatments having significant yield differences between the cutting management systems. The stand ratings of orchardgrass were not affected by cutting management. In the spring of 1997, however, the stand ratings of alfalfa-orchardgrass in the 4-cutting management system were significantly greater than the 5-cutting management system. The very high manure application rate significantly reduced the stand ratings of alfalfa-orchardgrass in the 5-cutting system. (***Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 5 : 630-635***)

Key Words : Cutting Management Systems, Nutrient Management, Manure

INTRODUCTION

Cutting management can be one of the important factors determining forage yield, forage quality, and stand persistence (Trimble et al., 1987; Sheaffer and Marten, 1990; Farnham and George, 1994; Jung et al., 1996; Hall, 1998). In birdsfoot trefoil (*Lotus corniculatus* L.)-orchardgrass communities, herbage dry matter yields were greater under the three-cut system (8.8 Mg/ha) than the six-cut system (6.4 Mg/ha) in Iowa (Farnham and George, 1994).

In research on clipping frequency and nitrogen fertilizer application, Jung et al. (1974) reported that herbage yields of orchardgrass were reduced the most by frequent clipping (8 cuts per year, 21-day intervals) at the low rate of N (56 kg/ha) as compared to infrequent cuttings (3 cuts per year, 55-day intervals) at the high rate of N (112 kg/ha). Hall (1998) in Pennsylvania reported that during dry years, harvesting orchardgrass, reed canarygrass (*Phalaris arundinacea* L.), smooth bromegrass (*Bromus inermis* Leyss.), and timothy (*Phleum pratense* L.), less frequently produced the greatest yields. In contrast, during years with normal or above normal rainfall, the low yields previously associated with frequent harvest intervals were less pronounced. It has been reported that nitrogen fertilizer stimulates the utilization of carbohydrate reserves and gives additional stress on orchardgrass, especially in combination with frequent removal of top growth (Colby et al., 1965; Reynolds, 1969).

When municipal wastewater effluent was applied to alfalfa and seven grasses at rates of 5 and 10 cm/wk, Marten et al. (1979) reported that alfalfa did not persist sufficiently well beyond the 2nd year due to a root-rot complex. Tall fescue (*Festuca arundinacea* Schreb.) and orchardgrass cut 4x/yr were among the best yielders for all three treatments. At the high effluent rate treatment (668 kg N/ha), herbage yields of orchardgrass were significantly higher than alfalfa in each of the cutting management systems (2, 3, and 4x/yr).

Orchardgrass and alfalfa-orchardgrass are common forage species in Maryland. Adequate data, however, are not available to determine how frequency of cuttings combined with dairy slurry application affect forage production and stand persistence. The objective of this study was to compare the effects of cutting management systems on herbage yield and stand persistence of orchardgrass and alfalfa-orchardgrass

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mixture fertilized with dairy slurry applied at several rates and frequencies during the growing season.

MATERIALS AND METHODS

Field studies were established in 1994 at the Central Maryland Research and Education Center-Clarksville Facility (Clarksville, Maryland, USA, 39° 15' N, 76° 56' W, elevation 111 m). The experiment was conducted on a moderately well-drained Delanco silt loam soil (fine-loamy, mixed, mesic Aquic Hapludults). Soil test results prior to initiation of the experiment showed high levels of both P (32 mg/kg) and K (82 mg/kg), soil pH 7.1 (1:1 by volume water:soil) and organic matter 26.5 g/kg.

Dairy cattle bedded pack manure from an uncovered stockpile was broadcast on the soil surface at the rate of 67 Mg/ha and immediately incorporated by disking on April 27, 1994. The manure contained 10.5, 2.3, and 10.2 kg/Mg total N, P, and K, respectively.

A randomized complete block design with treatments in a sub-subplot arrangement with 4 replicates was used. Main plots consisted of two cutting management systems (4 and 5 harvests per year), subplots were 9 fertility rate treatments (7 dairy slurry rate and frequency of application treatments, one inorganic fertilizer treatment, and an unfertilized control (no manure or fertilizer), and sub-subplots consisted of two forage species (orchardgrass and alfalfa-orchardgrass mixture). Subplots were 3.66×6.10 m with 0.91 m borders between treatments and 1.20 m between replications. Each 0.91×6.10 m sub-subplot contained 5 plant rows with 15 cm spacing. Sub-subplots were separated by 30 cm border. Plots were seeded May 23-24, 1994 with 'WL 320' alfalfa and 'Dawn' orchardgrass. The seeding rates were: orchardgrass, 4.54 kg/ha and alfalfa-orchardgrass, 6.36 and 1.36 kg/ha.

Manure applications and data collection were initiated after the first harvest in May 1995. Dates and N, P, and K rates of manure applications are given in tables 1 and 2. Manure application rates were targeted to supply 200, 300, 400 and 500 kg plant available nitrogen (PAN)/ha/yr. Since manure applications were not initiated until after the first cutting in 1995, application rates were reduced accordingly the first year. Manure nutrient analysis was performed by the University of Maryland Soil Testing Laboratory. The PAN values reported by the laboratory for surface applied manure (without soil incorporation) are based on organic nitrogen having 35% mineralization rate during the year of application and 100% ammonium nitrogen loss. However, since PAN can vary with climatic conditions following application and thus are not absolute values, N application rates are presented as total N (organic N+ammonium N). Manure used for the study was taken from a pit that stored solids scraped from the alleyways of a free-stall housing barn. The solids were loaded into a water-tight box manure spreader. To liquefy the solids, water was sprayed into the box spreader and liquid then pumped into a liquid spreader tank. Average solids content of the slurry was 8%. To minimize settling of solids in the tank during the application process, a manure pit agitator was placed in the tank and continuously operated. In addition, a 319 cc gasoline engine powered trash pump outside of the liquid spreader tank continuously withdrew slurry from the tank to fill 10.4 L garden watering cans for manual application to the plots. Excess slurry was recirculated to the tank.

Table 1. Dairy slurry application times and N (organic+ammonium), P, and K rates in the 4- and 5-cut systems, 1995

	N rates and application times						Total application					
	After 1st cut		After 3rd cut		After 4th cut							
4-cut	(06-20-95)		(08-25-95)		-							
5-cut	(06-15-95)		(08-09-95)		(09-12-95)		N		P		K	
	Cutting system											
Fertility rates	4	5	4	5	4	5	4	5	4	5	4	5
	kg/ha											
1. Low manure	137	111	278	65	0	264	415	440	40	58	279	398
2. Low manure	274	222	139	65	0	132	413	419	41	55	281	364
3. Medium manure	274	222	417	195	0	264	691	681	66	86	466	583
4. Medium manure	411	333	278	65	0	264	689	662	69	83	471	548
5. High manure	274	222	556	97	0	528	830	847	79	109	558	745
6. High manure	548	444	278	97	0	264	826	805	82	103	563	603
7. Very high manure	411	333	556	130	0	528	967	991	93	128	652	872
8. Inorganic fertilizer	224	224	0	0	0	0	224	224	37	37	279	279
9. Control	0	0	0	0	0	0	0	0	0	0	0	0

Table 2. Dairy slurry application times and N (organic+ammonium), P, and K rates in the 4- and 5-cut systems, 1996

	N rates and application times										Total application					
	Early spring		After 1st cut		After 2nd cut		After 3rd cut		After 4th cut							
4-Cut	(04-24-96)		(05-31-96)		(07-25-96)		(08-26-96)		-							
5-Cut	(04-20-96)		(05-31-96)		(07-25-96)		(08-26-96)		(10-05-96)		N		P		K	
	Cutting system															
Fertility rates	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5
	kg/ha															
1. Low manure	217	227	161	194	203	192	209	0	0	224	790	837	79	83	424	388
2. Low manure	434	454	0	0	406	384	0	0	0	0	840	838	80	74	505	419
3. Medium manure	434	454	322	194	203	192	209	242	0	224	1,168	1,306	122	128	682	674
4. Medium manure	868	681	0	0	406	384	0	0	0	224	1,274	1,289	108	114	728	676
5. High manure	434	454	322	388	406	384	418	242	0	224	1,580	1,692	165	172	928	872
6. High manure	868	908	322	0	203	576	209	0	0	224	1,602	1,708	151	149	905	870
7. Very high manure	868	454	322	388	406	384	418	484	0	224	2,014	1,934	194	217	1,150	1,017
8. Inorganic fertilizer	168	112	112	112	112	112	112	112	0	56	560	560	37	37	279	279
9. Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Manure samples were taken periodically as the tank was unloaded to monitor consistency of the slurry as it was being applied. The mean of all samples was used to calculate the N, P, and K application rates. For the inorganic fertilizer treatment, 224 kg N/ha as NH_4NO_3, 37 kg P/ha and 279 kg K/ha were applied in 1995. In 1996, 560 kg N/ha as NH_4NO_3, 37 kg P/ha and 279 kg K/ha were applied.

The study was initiated after 1st cutting in 1995. The cutting dates for the 4-cutting management system experiment in 1995 were May 25, July 13, August 23, and November 21. Cutting dates in 1996 were May 23, July 10, August 20, and October 29. In the 5-cutting management system, the cutting dates in 1995 were May 23, July 6, August 8, September 11, and November 28. Cutting dates in 1996 were May 20, July 9, August 7, September 20 and November 20. Forage yields were determined by cutting 0.90 × 6.10 m areas of the plots to a 7-cm stubble height using a Carter Harvester (flail-type). The harvested herbage was captured in a canvas bag and weighed to measure the fresh weight yield from each plot. Subsamples (800 to 1000 g wet weight) were taken from the harvested herbage of plots for moisture determination and samples were dried at 60℃ for 72 hr. Forage stands (percentage of ground cover) were independently estimated by three scientists in the spring of 1996 and 1997 after plants had initiated growth. Values were expressed as the mean of the three estimates. A perfect stand was defined as one in which 100% of the plants were the designated species and in which 100% ground cover existed.

Total annual precipitation (rain+snow) was 1,340 mm in 1995 and 1,673 mm in 1996 (January-November) (table 3). These precipitation amounts were above the 30-yr mean total precipitation of 1,164 mm. Total precipitation during the March through October growing season was 737 and 1,101 mm for 1995 and 1996, respectively. The 30-yr mean average precipitation for this period is 815 mm. June, July, and September 1995 were considerably drier than normal. Considerably above average normal precipitation was received in January, February, June, July, and September 1996. The average monthly temperatures in 1995 and 1996 were close to the normal.

Data were subjected to analysis of variance to test the effects of cutting management systems, fertility rates, species, and cutting management × fertility rates × species interaction using PROC MIXED (SAS/STAT, 1996). Cutting management, fertility rates, species and cutting management × fertility rates × species were considered as fixed effects. Means were separated using Fisher's protected least significant difference (LSD) test with an alpha level of 0.05.

RESULTS AND DISCUSSION

Herbage yield

Mean cumulative yields of the 2nd and subsequent cuttings of orchardgrass and alfalfa-orchardgrass over all fertility treatments in 1995 were higher for the 5-cutting system than for the 4-cutting system (table 4). However, the differences between cutting systems for individual fertility treatments were only significant for the very high manure rate (treatment 7) in the case of orchardgrass and the inorganic fertilizer and control treatments (8 and 9) in the case of the alfalfa-orchardgrass mixture. Clapp et al. (1984), using municipal wastewater effluent in Minnesota, reported the two, three, or four times/yr cutting frequency had

Table 3. Monthly rainfall and air temperature, 1995, 1996 and 30-yr mean

Month	Rainfall			Air temperature		
	1995	1996	30-yr	1995	1996	30-yr
	mm			℃		
January	104	211	91	2.8	-1.7	-0.6
February	239	234	71	-2.2	0.0	1.1
March	53	104	97	7.2	3.9	6.1
April	48	99	91	10.6	11.7	11.1
May	135	147	124	16.7	17.2	16.7
June	86	150	104	22.2	22.8	21.7
July	46	208	107	25.6	23.3	23.9
August	104	119	102	24.4	22.2	23.3
September	97	157	99	18.9	19.4	19.4
October	168	117	91	11.1	12.8	12.8
November	147	127	94	3.9	4.4	7.2
December	122	-	94	0.0	-	2.2

Table 4. Effects of cutting frequency on herbage yield of orchardgrass (OR) and alfalfa-orchardgrass (AL-OR) fertilized with surface-applied dairy slurry and inorganic fertilizer in 1995

Fertility rates	OR		AL-OR	
	Cutting system			
	4	5	4	5
	Mg/ha			
1. Low manure	7.0[a]	6.9[a]	10.4[a]	11.3[a]
2. Low manure	6.6[a]	7.2[a]	11.2[a]	11.3[a]
3. Medium manure	8.2[a]	8.1[a]	11.2[a]	11.0[a]
4. Medium manure	7.7[a]	8.6[a]	10.6[a]	11.8[a]
5. High manure	8.2[a]	9.0[a]	10.9[a]	11.2[a]
6. High manure	7.9[a]	8.6[a]	10.4[a]	10.6[a]
7. Very high manure	7.5[a]	9.1[b]	11.0[a]	11.9[a]
8. Inorganic fertilizer	7.3[a]	7.7[a]	10.2[a]	11.7[b]
9. Control	4.8[a]	5.0[a]	8.6[a]	10.6[b]
Mean[1]	7.2	7.8	10.5	11.3

[a,b] Means within a row for each species followed by the same letter are not significantly ($p<0.05$) different.

[1] LSD (0.05)=0.9 for mean comparisons of cutting management systems within species.

Table 5. Effects of cutting frequency on herbage yield of orchardgrass (OR) and alfalfa-orchardgrass (AL-OR) fertilized with surface-applied dairy slurry and inorganic fertilizer in 1996

Fertility rates	OR		AL-OR	
	Cutting system			
	4	5	4	5
	Mg/ha			
1. Low manure	16.2[a]	15.5[a]	19.0[a]	17.1[a]
2. Low manure	16.4[a]	15.2[a]	17.5[a]	17.4[a]
3. Medium manure	18.0[a]	16.9[a]	19.5[b]	17.2[a]
4. Medium manure	19.0[b]	16.4[a]	17.5[a]	17.8[a]
5. High manure	17.3[b]	16.6[a]	19.9[b]	17.7[a]
6. High manure	17.8[b]	15.7[a]	16.7[a]	16.5[a]
7. Very high manure	18.2[a]	16.2[a]	19.5[b]	16.5[a]
8. Inorganic fertilizer	16.2[a]	16.4[a]	18.0[a]	16.5[a]
9. Control	10.3[a]	11.6[a]	15.3[a]	16.0[a]
Mean[1]	16.6	15.6	18.1	17.0

[a,b] Means within a row for each species followed by the same letter are not significantly ($p<0.05$) different.

[1] LSD (0.05)=0.9 for mean comparisons of cutting management systems within species.

little effect on root length or dry weight, whereas wastewater treatment levels caused significant root differences. The high effluent (590 kg N/ha) treatment produced less root length and root mass in reed canarygrass, orchardgrass, tall fescue, and Kentucky bluegrass (*Poa pratensis* L.) compared with the control and low effluent (332 kg N/ha).

Orchardgrass and the alfalfa-orchardgrass mixture responded somewhat differently to the influence of cutting management and fertility treatments in 1996. Mean yield of orchardgrass over all fertility treatments for the 4-cutting management system was significantly higher than for the 5-cutting management system (table 5). However, when cutting system yields were compared for each fertility treatment, only treatments 4 and 6 (less frequent applications of the medium and high manure rates) were significantly different. Higher application rates early in the growing season appear to have increased the yield of these treatments. This would be expected since much of the annual production of cool-season grasses is early in the growing season and there is likely to be less response to higher manure or fertilizer application rates later in the season. Treatments 4, 6, and 7 had higher manure

application rates in early spring and after 1st cutting in the 4-cutting management system than in the 5-cutting management system (table 2). Treatments 4, 6, and 7 received a combined total of 868, 1,190, and 1,190 kg total N/ha, respectively (equivalent to approximately 211, 297, and 297 kg plant available N/ha) in the 4-cutting system vs. 681, 908, and 842 kg total N/ha (approximately 169, 225, and 277 kg PAN/ha) in the 5-cutting system.

Inspection of the yields for individual cuttings showed that the yield differences between cutting management systems for treatments 4 and 6 occurred primarily in the 1st and 2nd cuttings. First and second cuttings for treatment 7 in the 4-cutting system were similar to treatments 4 and 6 but treatment 7 had the highest combined 1st and 2nd cutting yield in the 5-cutting management system so there was no significant difference due to cutting management for treatment 7.

Mean yield of alfalfa-orchardgrass over all fertility treatments was likewise significantly higher for the 4-cutting management system than the 5-cutting management system. However, with alfalfa-orchardgrass it was the more frequent applications of manure at the medium and high rates (treatments 3 and 5) and the very high rate (treatment 7) that had increased yields compared to the same treatments in the 5-cutting system (table 5). As previously reported (Min et al., 1999), yields for the 4-cutting system treatments 3, 5, and 7 had significantly higher yields than treatments 2, 4, and 6. Inspection of the yields for individual cuttings again showed that the yield differences between cutting management systems occurred primarily in the 1st and 2nd cuttings. Third and 4th cuttings yields in the 4-cut system and yields of all cuttings in the 5-cutting system were relatively uniform across all fertility treatments except the control.

While orchardgrass appeared to respond to higher applications of manure in early spring, this does not appear to be the case with alfalfa-orchardgrass. The yield responses of alfalfa-orchardgrass correspond most closely with manure applications after 3rd cutting the previous year. The response of alfalfa-orchardgrass is particularly difficult to explain and we question whether the response differences are real or artificial. Further investigation is needed.

Stand ratings

There were no significant differences in stand ratings of orchardgrass between the 4- and 5-cutting management systems in the spring of 1996 and 1997 (table 6). This study suggests that if split applications are made properly, a high rate of dairy slurry (up to about 2,000 kg total N/ha) can be applied to orchardgrass without having a detrimental effect on stand persistence in either a 4- or 5-cutting management system. In research on clipping frequency and nitrogen fertilizer application in West Virginia (Jung et al., 1974), stand persistence of orchardgrass improved as

Table 6. Effects of cutting frequeney on stand persistence of orchardgrass (OR) and alfalfa-orchardgrass (AL-OR) at various rates of fertilization with dairy slurry and inorganic fertilizer in the spring of 1996 and 1997

	OR				AL-OR			
	Year							
	96		97		96		97	
	Cutting system							
Fertility rates	4	5	4	5	4	5	4	5
	%							
1. Low manure	69[1]	63	67[2]	70	80[1]	76	77[2]	73
2. Low manure	65	61	68	63	80	76	78	68
3. Medium manure	65	65	65	68	75	72	75	66
4. Medium manure	59	62	61	65	76	78	77	69
5. High manure	61	65	69	69	72	70	80	67
6. High manure	62	56	63	61	73	70	76	66
7. Very high manure	61	63	62	56	73	68	77	50
8. Inorganic fertilizer	57	66	56	63	76	81	73	66
9. Control	70	67	72	69	71	77	79	73
Mean[3]	63	63	65	65	75	74	77	66

[1] LSD1 (0.05)=11.0 for cutting comparisons within same species and fertility rate in the spring of 1996.

[2] LSD2 (0.05)=10.0 for cutting comparisons within same species and fertility rate in the spring of 1997.

[3] LSD3 (0.05)=9 and 7 for mean comparisons of cutting systems averaged over fertility rates and species in the spring of 1996 and 1997, respectively.

clipping frequency increased from three (55-day intervals) to eight (21-day intervals) cuts per season, especially at the high rate of N (112 kg/ha).

There was a significant difference in stand ratings averaged over fertility rates between the 4- and 5-cutting systems for alfalfa-orchardgrass in the spring of 1997. The stand ratings in the 4-cutting management system (average 77%) were significantly greater than the 5-cutting system (average 66%). However only two of the individual slurry rate treatments (5 and 7) showed significant differences. The significant difference in the alfalfa-orchardgrass ratings in 1997 between the 4- and 5-cutting systems for treatment 5 is probably due to judgement error in rating. It is unlikely that the stand improved from a rating of 72 in 1996 to 80 in 1997. The very high manure rate (treatment 7) had a significantly lower stand rating in the 5-cutting system than in the 4-cutting system. Although the applications of manure after the 1st, 2nd, and 3rd cuttings in 1996 were on the same dates for both cutting systems and the rates were reasonably comparable between cutting systems, the 5-cutting system was affected to a much greater extent than the 4-cutting system.

SUMMARY

Cutting frequency did not affect orchardgrass stand ratings either year and only affected alfalfa-orchardgrass ratings at the very high slurry application rate the second year. When there were significant differences in yield due to cutting frequency in 1996, they were in favor of the 4-cutting management system, both for orchardgrass and the alfalfa-orchardgrass mixture. While these results favor the 4-cutting management system for dry matter yield, forage quality and nutrient yield (kg crude protein and digestible dry matter/ha) also need to be considered. Further research is in progress relating to this aspect.

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