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Nitrogen Fertilization of Grasses

by
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INTRODUCTION

High yields of high quality grass is an essential component of a successful grass forage production system. Cultural and soil fertility practices have a large impact on yield and quality of grass. In terms of soil fertility, nitrogen (N) is the most limiting nutrient in grass production in northeast. The objective of this component of our studies was to determine the response of several grass to additions of fertilizer N for two system of cutting management.

METHODS

Four experimental sites (Cornell research farms at Aurora, Mt. Pleasant, Caldwell Field, and Valatie) were chosen for their representation of important physiographic regions in New York. Soil type at the locations were: Lima (moderately well drained, calcareous glacial till) at Aurora; Collamer (moderately well drained, calcareous alluvial materials) at Caldwell Field; Mardin (moderately well drained, acid glacial till) at Mt. Pleasant; and Hoosic (excessively drained, acid gravel outwash) at Valatie.

The factorial design included two grass species, at two levels of cutting management, and 5 levels of fertilizer N. Each treatment was replicated 4 times. The two grass species were reed canarygrass and timothy at the Aurora, Mt. Pleasant, and Caldwell Field locations, and reed canarygrass and orchardgrass at Valatie. The two levels of cutting management were 3 and 4 cuttings per season. The first cutting for the 3 cut system began at the first appearance of heading, and when the grass contained approximately 55% NDF (about early boot stage) for the 4 cut system. The same stage of maturity for each cutting management system was used to determine subsequent harvests. Five rates of fertilizer N (0, 60, 120, 240, and 480 lbs. N/ac) were superimposed over each specie and cutting treatment. Nitrogen was topdressed as ammonium nitrate according to the schedule in Table 1.

Plant samples were taken after each cutting and analyzed for N at all sites except for Valatie. The N analysis for 1997 was not complete at this writing.

Soil samples were collected and analyzed annually. An annual application of fertilizer P and K was applied to all treatments based on soil test results. At the Aurora, Caldwell Field, and Mt. Pleasant sites, 80 and 160 pounds of P_2O_5 and K_2O, respectively were topdressed in the early spring each year. The same rate of P_2O_5 and K_2O was topdressed in the early spring at Valatie in 1994-95, and 60 and 360 pounds per acre, respectively in 1996-97.

The Mt. Pleasant and Valatie sites were seeded in late summer of 1993 and data collection began in the spring of 1994. The Aurora and Caldwell Field sites were seeded in late summer of 1994 and data collection began in the spring of 1995.

The fertilizer N response model and economic fertilizer N rate for each treatment combination, was done by regression analysis using the yearly price of fertilizer N ($.25, and $.28 per pound for 1994, and 1995-97, respectively), market value of grass hay of $80 per ton, and fixed costs of $180 and $225 per acre for the establishment and topdressing years, respectively.

RESULTS and DISCUSSION

Forage production is very dependent on rainfall. Table 2 shows the precipitation for all locations during the April 1 to September 30 growing season. Precipitation in 1994 was above average at Mt. Pleasant and slightly below average at Valatie. Precipitation was considerably below average in 1995 and 1997 and above average in 1996 at all locations. The least rainfall occurred at Valatie during the 1997 growing season.

Yield, economic fertilizer N rate, and the regression equations are shown in Figure 1. These data are separated by specie, cutting management, and year within each location. Yield and variability in yield was a function of the growing season precipitation (compare maximum yields in Figure 1 with precipitation in Table 2). There was a strong relationship between yield and fertilizer N, as evidenced by the high R^2. Without exception, maximum yield was greater under a 3 cut as compared to a 4 cut system.

The economic fertilizer N rate was calculated for each response function based on that years cost of fertilizer N, value of grass hay, and fixed costs. As expected, economic N rates (shown in Figure 1 and summarized in Table 3) varied between grass specie, location and year. Economic N rates were higher for reed canarygrass then for timothy, and higher for 4 cuttings as compared to 3, even though the 3 cut system had the greater yield. At Valatie, reed canarygrass required more N then orchardgrass to achieve maximum economic yield.

Total N uptake and the percent recovery of applied fertilizer N for reed canarygrass and timothy was determined at the Aurora (1995-96), Caldwell Field (1995-96), and Mt. Pleasant (1994-96) sites (Table 4). Nitrogen uptake increased with increasing N input. Percent N recovery ranged from 26 to 93 percent of the applied fertilizer N, and maximized at the first or second increment of N input (60 or 120 lb./ac/yr) but decreased markedly with a further increase in N.

Protein content could not be accurately estimated, by the often used method of multiplying the percent total N in the above ground dry matter by 6.25, because of the large amount of non-protein N (as nitrate) present in some treatments. Total N uptake should be corrected for non protein N before the protein content is estimated.

An important consideration when formulating N recommendations for forages is the affect of N input on nitrate N concentration in the above ground dry matter. Excessive additions of N can cause elevated levels of nitrate. Animal nutritionist recommend that the concentration of nitrate N in forage not exceed 1000 ppm on a dry matter basis. High levels of nitrate in cattle diets can reduce feed intake, milk production, reproductive efficiency, and at extremely high levels, death.

Nitrate N concentrations were determined on a limited basis in this study (additional analyses are underway). Table 5 shows the concentrations for 2 N rates at 3 locations in 1995. Table 6 shows the concentrations in reed canarygrass and timothy, for 2 replicates and 4 N rates, at the Mt. Pleasant site in 1996. Preliminarily, the data in Tables 5 and 6 suggests that concentrations exceeding 1000 ppm occur frequently, and occur more often in a 4 cut as compared to a 3 cut system. Tentatively, fertilizer N rates exceeding about 240 pounds per acre per year may be undesirable when nitrate N concentration is an important consideration. Further research will hopefully more clearly define the relationship between N input and nitrate concentration in forage under a wide range of growing conditions.

Table 1. Time of nitrogen applications.

Time	N rate, lb/ac 0	60	120	240	480
spring, early greenup	0	60	80	120	240
after 1st cut	0	0	40	80	120
after 2nd cut	0	0	0	40	120

Table 2. Precipitation (in.) during the growing season (4/1-9/30).

Location	Year 1994	1995	1996	1997	30 yr. mean
Aurora	-	16.56	25.43	17.65	20.58
Caldwell Field	-	12.52	26.47	16.34	20.41
Mt. Pleasant	30.41	14.54	34.06	20.72	22.53
Valatie	22.47	14.73	33.99	10.03	23.87

Table 3. Economic fertilizer N rates for each treatment combination.

Specie	Cuts	Location	Economic N rate, lb/a 1994	1995	1996	1997	Mean
Timothy	3	Aurora	*	205	370	225	265
		C. Field	*	125	210	235	190
		Mt. Pleasant	365	320	285	240	300
		mean	365	217	288	233	252
	4	Aurora	*	220	350	230	265
		C. Field	*	255	305	255	270
		Mt. Pleasant	390	355	240	275	315
		mean	390	277	298	253	283
Reed C	3	Aurora	*	375	340	360	360
		C. Field	*	45	240	300	195
		Mt. Pleasant	400	330	380	370	370
		Valatie	280	355	200	220	265
		mean	340	276	290	312	298
	4	Aurora	*	320	>480	310	>370
		C. Field	*	260	415	365	345
		Mt. Pleasant	415	315	445	350	380
		mean	415	298	>445	342	>365
Orchard	3	Valatie	275	290	160	145	215

* not established in 1994.

Table 4. Total N uptake (lb/a) and recovery (%) of applied fertilizer N.

			Location, Year													
			Aurora				Caldwell Field				Mt.Pleasant					
			1995		1996		1995		1996		1994		1995		1996	
Specie	Cuts	N lb/a	N uptake	recovery	N uptake	recovery	N uptake	recovery	N uptake	recovery	N uptake	recovery	N uptake	recovery	N uptake	recovery
Timothy	3	0	38		25		65		69		35		17		28	
		60	73	58	75	82	89	40	122	88	75	65	44	45	72	73
		120	85	39	98	61	124	49	166	81	101	49	61	37	140	93
		240	110	30	150	52	142	32	226	66	160	52	103	36	189	67
		480	169	27	211	39	188	26	304	49	244	43	154	29	241	44
	4	0	27		22		65		64		35		17		25	
		60	63	60	65	73	93	47	119	91	71	65	43	43	70	75
		120	83	47	100	64	109	37	151	71	127	74	50	27	107	68
		240	117	37	170	62	165	42	241	74	189	63	97	33	201	73
		480	156	27	206	38	218	32	298	49	249	56	159	29	240	45
Reed C	3	0	30		27		105		88		45		22		35	
		60	69	65	77	81	134	48	133	75	88	72	46	40	74	65
		120	84	45	112	70	129	20	156	56	119	62	60	32	137	85
		240	117	36	170	59	160	23	236	61	175	54	101	33	193	66
		480	207	37	296	55	242	29	320	48	289	51	155	28	281	51
	4	0	32		32		83		73		45		25		44	
		60	66	57	66	64	103	33	105	53	85	61	47	37	76	53
		120	84	43	109	68	142	49	166	77	137	77	55	25	114	58
		240	146	47	179	61	200	49	236	67	216	71	105	33	195	63
		480	212	37	313	58	279	41	363	61	315	56	181	33	284	50

Table 5. Effect of cutting management and fertilizer N rate on nitrate N content in grass 1995[1].

Cuts	N rate lb/a	Aurora	Location C. Field	Mt. Pleasant
			NO_3N, ppm	
3	240	592	572	528
	480	1223	2516	2697
4	240	652	694	606
	480	1865	2377	3411

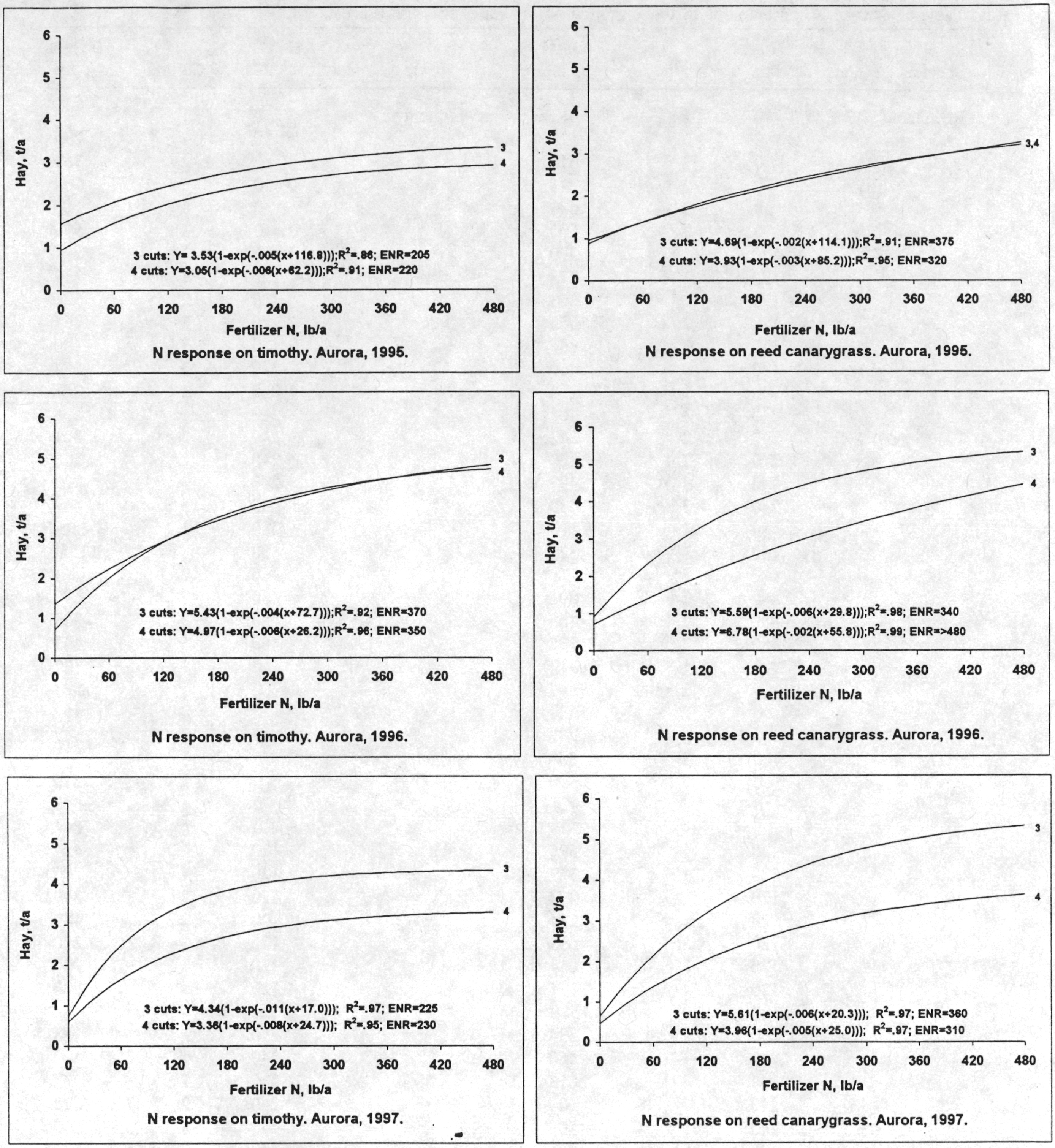
[1]means of 2 replicates, 2 species, and 3 or 4 harvest dates.
Source: J.C. Cherney 1995. Cornell Univ.

Table 6. Nitrate N concentration in above ground dry matter of two grass species. Mt. Pleasant, 1996.

Specie	Cuts	N rate lb/a	Cutting	NO3-N ppm	Specie	Cuts	N rate lb/a	Cutting	NO3N ppm
Reed can.	3	0	1	682	Timothy	3	0	1	333
		0	1	628			0	1	295
		0	2	615			0	2	361
		0	2	241			0	2	334
		0	3	683			0	3	186
		0	3	600			0	3	559
		120	1	390			120	1	294
		120	1	373			120	1	239
		120	2	363			120	2	520
		120	2	585			120	2	294
		120	3	682			120	3	200
		120	3	469			120	3	574
		240	1	334			240	1	241
		240	1	402			240	1	295
		240	2	362			240	2	321
		240	2	240			240	2	360
		240	3	497			240	3	227
		240	3	430			240	3	469
		480	1	1210*			480	1	1160*
		480	1	372			480	1	1550*
		480	2	1578*			480	2	1279*
		480	2	801			480	2	679
		480	3	468			480	3	360
		480	3	535			480	3	469
	4	0	1	1042*		4	0	1	375
		0	1	669			0	1	523
		0	2	439			0	2	469
		0	2	227			0	2	387
		0	3	800			0	3	374
		0	3	590			0	3	na
		0	4	1321*			0	4	669
		0	4	1308*			0	4	894
		120	1	576			120	1	427
		120	1	387			120	1	306
		120	2	373			120	2	359
		120	2	214			120	2	457
		120	3	655			120	3	280
		120	3	614			120	3	706
		120	4	1177*			120	4	920
		120	4	1588*			120	4	1162*
		240	1	334			240	1	388
		240	1	480			240	1	400
		240	2	615			240	2	1526*
		240	2	401			240	2	670
		240	3	508			240	3	240
		240	3	467			240	3	534
		240	4	1001*			240	4	897
		240	4	1446*			240	4	1042*
		480	1	1147*			480	1	1232*
		480	1	1269*			480	1	2236*
		480	2	3043*			480	2	1480*
		480	2	1870*			480	2	778
		480	3	992			480	3	266
		480	3	1495*			480	3	1204*
		480	4	906			480	4	800
		480	4	1174*			480	4	950

* nitrate nitrogen concentrations exceed 1000 ppm

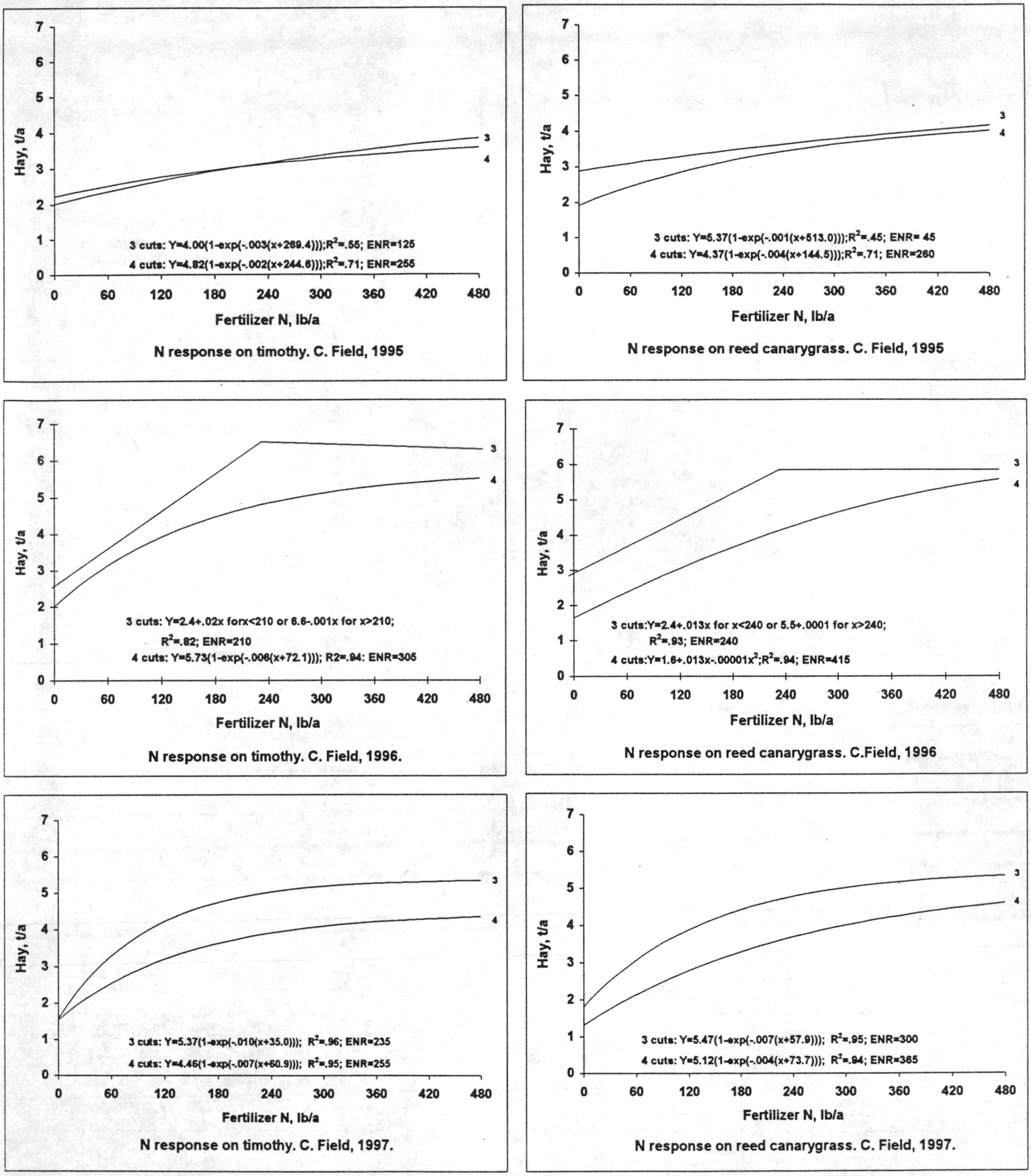
Location: Aurora Farm



* Y= predicted yield; R^2 = coefficient of determination; ENR = economic N rate (lb/a).

Figure 1. Yield and economic fertilizer N rate by specie, cutting management, year, and location.

Location: Caldwell Field



N response on timothy. C. Field, 1995

N response on reed canarygrass. C. Field, 1995

N response on timothy. C. Field, 1996.

N response on reed canarygrass. C.Field, 1996

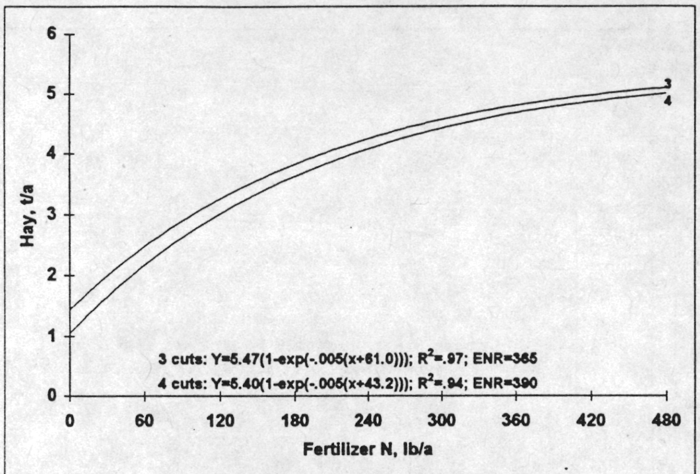
N response on timothy. C. Field, 1997.

N response on reed canarygrass. C. Field, 1997.

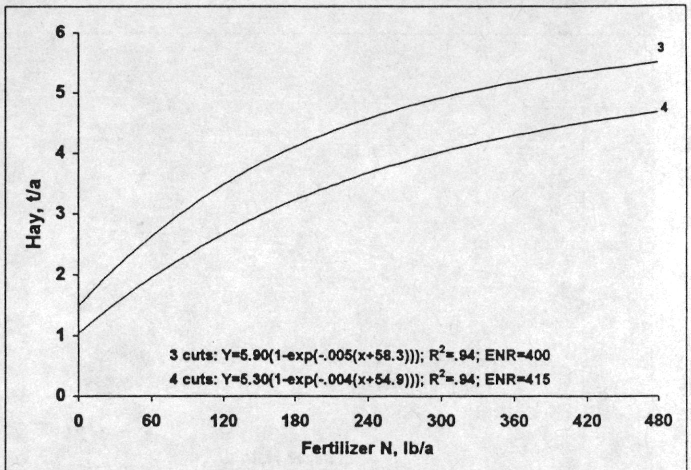
* R^2 = coefficient of determination; ENR = economic N rate (lb/a).

Figure 1 (cont).

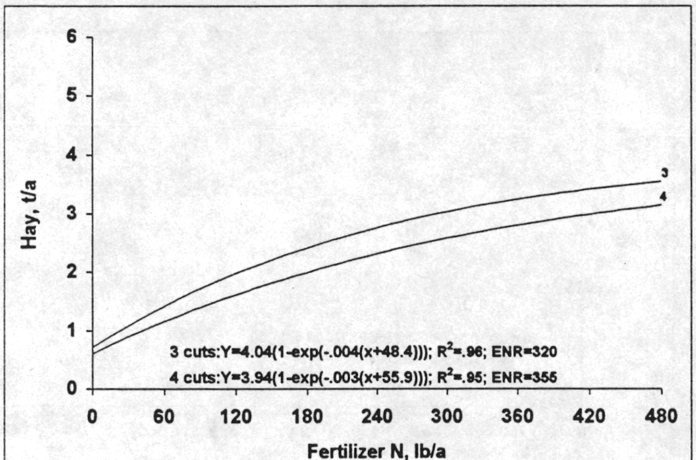
Location: Mt. Pleasant Farm



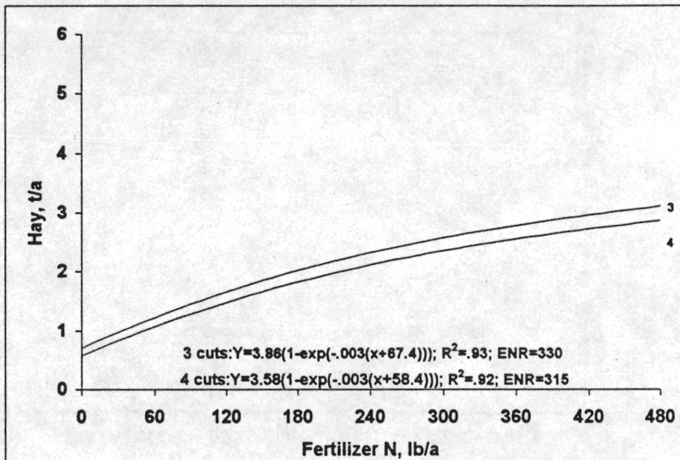
N response on timothy. Mt. Pleasant, 1994



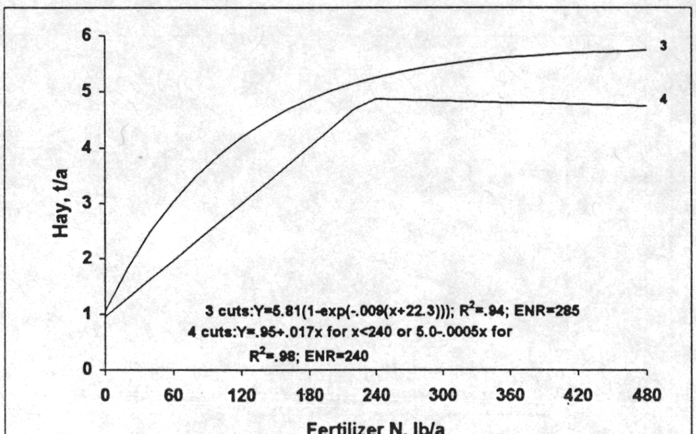
N response on reed canarygrass. Mt Pleasant, 1994



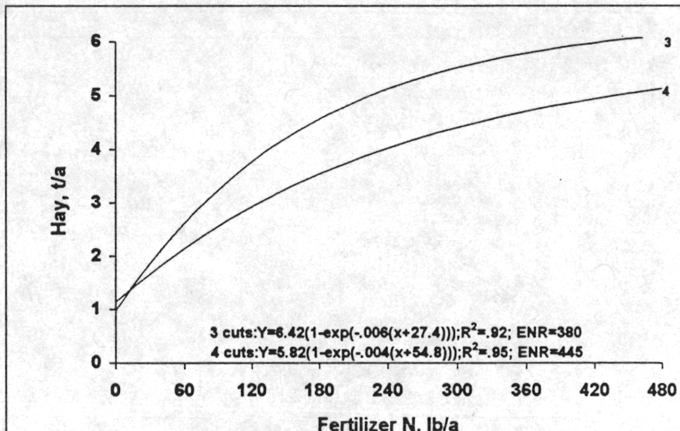
N response on timothy. Mt Pleasant, 1995



N response on reed canarygrass. Mt Pleasant, 1995

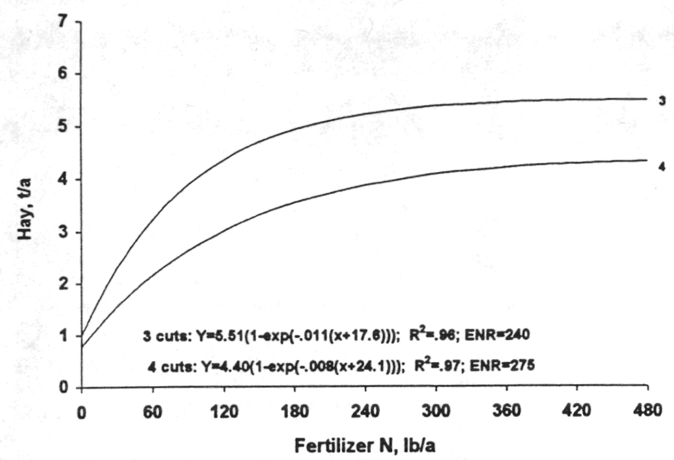


N response on timothy. Mt. Pleasant, 1996

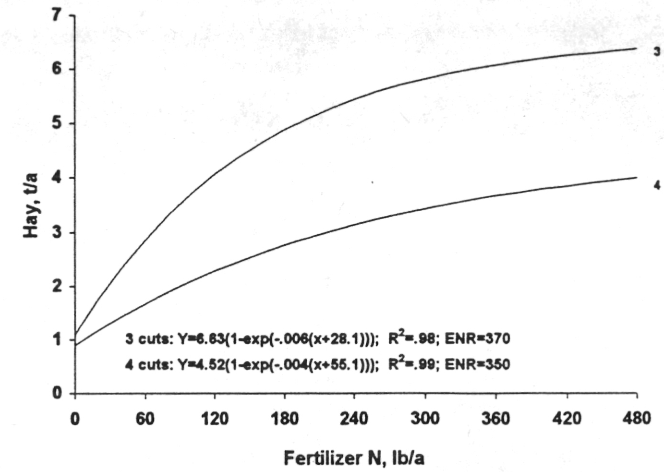


N response on reed canarygrass. Mt Pleasant, 1996

Location: Mt. Pleasant Farm (cont.)



N response on timothy. Mt. Pleasant, 1997.

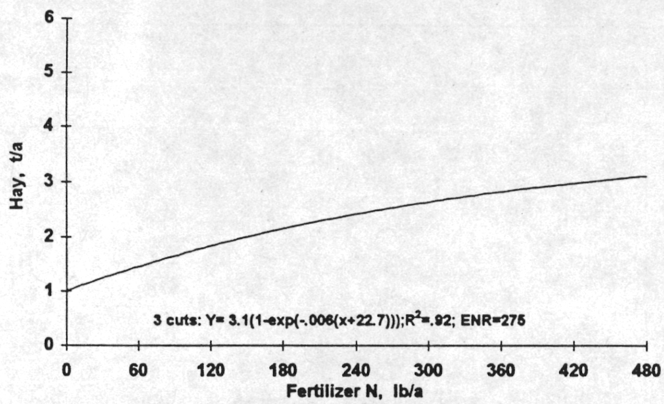


N response on reed canarygrass. Mt. Pleasant, 1997.

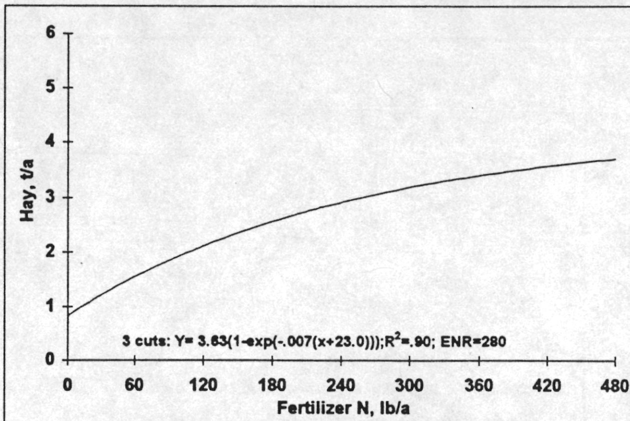
* R^2 = coefficient of determination; ENR = economic N rate (lb/a).

Figure 1. (Cont).

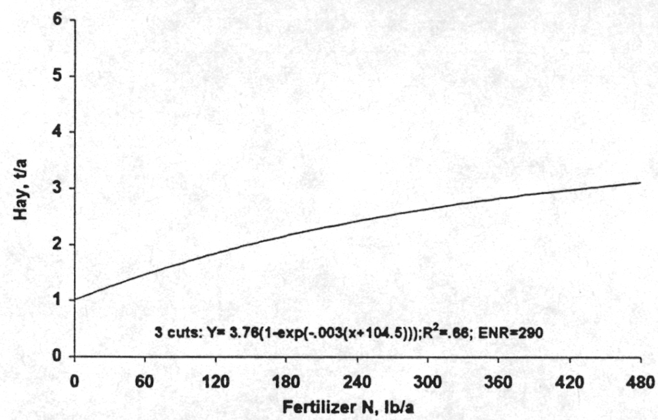
Location: Location: Valatie Farm



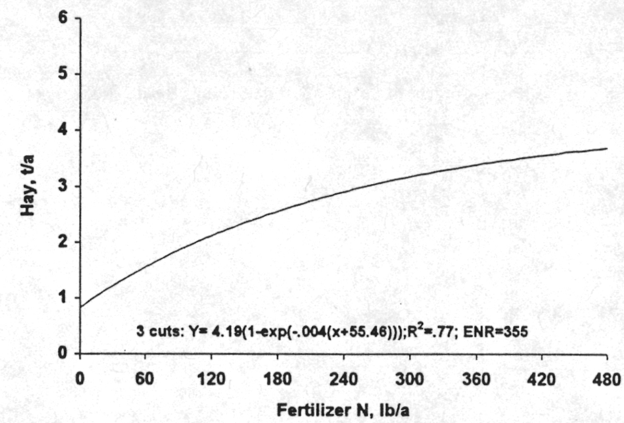
N response on orchardgrass. Valatie, 1994.



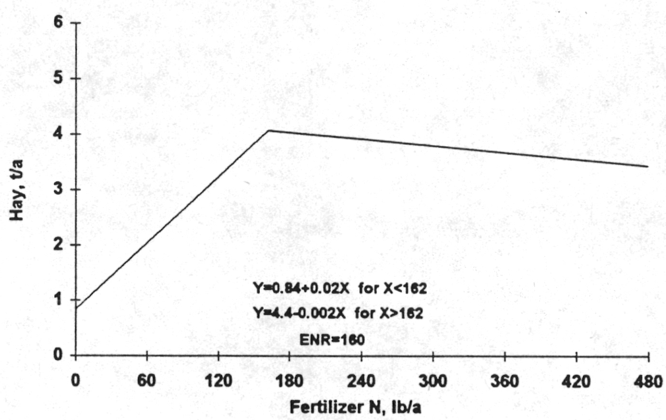
N response on reed canarygrass. Valatie, 1994.



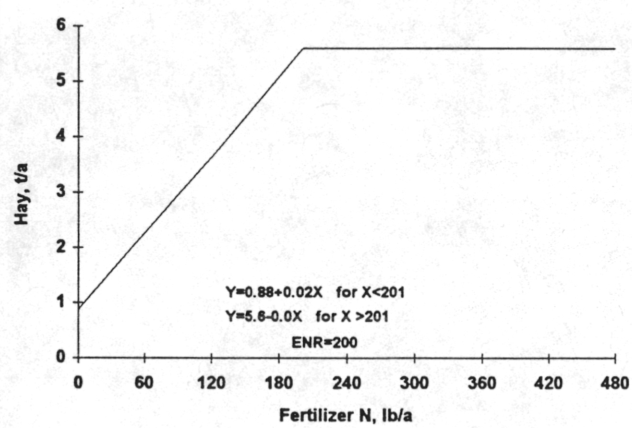
N response on orchardgrass. Valatie, 1995.



N response on reed canarygrass. Valatie, 1995.

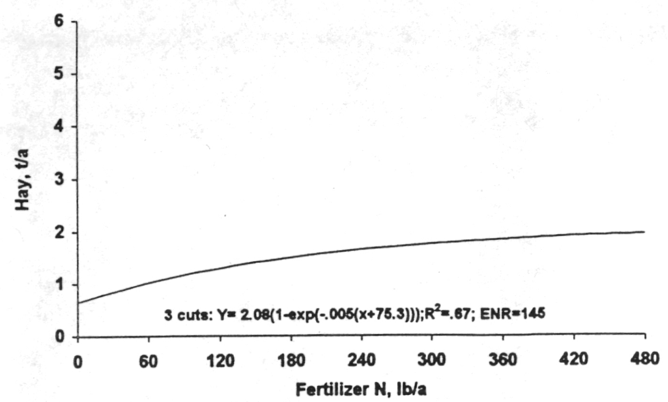


N response on orchardgrass, Valatie 1996.

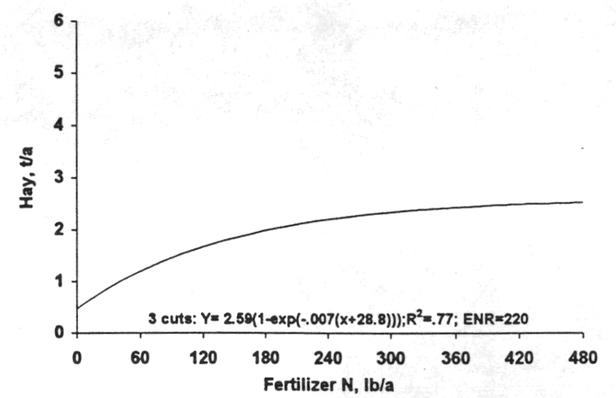


N response on reed Canarygrass, Valatie 1996.

Location: Valatie Farm (cont.)



N response on orchardgrass. Valatie, 1997.



N response on reed canarygrass. Valatie, 1997.

*** R^2 = coefficient of determination; ENR = economic N rate (lb/a).**

Figure 1 (Cont).