

Nitrogen Impact on Yield and Quality of Export Timothy Hay

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Production of timothy hay for export to Japan and Korea has proven to be a profitable enterprise for many Manitoba growers and processors. These markets are looking for a source of fibre to add to high concentrate rations for dairy and beef cattle. Although traditional forage quality as determined by high digestibility and protein is not desired, specific quality parameters are required in order to receive high prices. These prices may range from \$60/t for low quality (graded as Utility) compared to the best quality at \$200/t (graded as Supreme) FOB at Manitoba compacting plants.

The 2 primary quality factors are lack of brown leaf material and green colour. Brown leaf is caused by natural senescence and/or diseases. Lesser quality parameters are head length and stem length (Jefferson et. al, 2001). The retention of high quality is desired over a wide harvest window – so growers can delay harvest to maximize yields and to position harvest into a period of lower rainfall probability, which contribute to quality deterioration in the swath. Growers and agronomists have observed that quality tends to deteriorate more with high nitrogen rates.

Several studies were conducted to identify practices that produce consistently high quality over a long harvest window. This project assessed the impact of nitrogen and other nutrient fertility management on timothy yield, and more important, the quality.

Materials and methods

Established timothy fields in the Swan River, Russell and Teulon areas were identified and fertilized with the following treatments:

- 1) Nitrogen rate studies: rates ranging from 0 up to 90-200 lb N/ac (rates differed among the 9 studies)
- 2) Nitrogen timing: all N applied in the early spring or delayed 2 and 4 weeks (6 studies). Nitrogen applications were 100 lb N/ac in 2000, applied between May 1. In 2001 the N rate was 60 lb N/ac and the first application was on May 9.
- 3) N split applications: all early spring vs. ½ early spring and remainder applied at 2, 4, 6 or 8 weeks later (7 studies). Initial N applications were on May 1-5 in 2000 and on May 9 in 2001. Total N applied was 100 lb N/ac in 2000 and 60 lb N/ac in 2001.

Nitrogen was broadcast applied as ammonium nitrate (34-0-0). Soil samples were taken at some but not all sites.

Individual plots were 4 m wide by 10 m long, in a Randomized complete block design (RCBD) and replicated 4 times. Yields were taken in mid July with a Swift Current flail plot harvester. Ratings were taken on lodging and plant growth parameters at some sites. Quality samples were taken at harvest, or at various times around the harvest time. Quality was visually assessed to determine grade and % brown leaf. Through development work by the Canadian Grain Commission and Canadian Hay Association, a computer image analysis system was developed to determine hay quality or “Hayscan” score. The Hayscan score is a combination of desired green colour and leaf area, with a high value indicating higher quality.

The data was analysed using ANOVA and only aggregate or significant data will be presented.

Results

Nitrogen Rates

At 7 of the 9 sites, the highest yield was achieved at the 80-90 lb N/ac rate (Table 1), which is similar to Manitoba guidelines for forage grasses. The Timothy Production Handbook published by the Canadian Hay Association in 1999 indicates that most producers growing timothy for hay under dryland conditions will not exceed 60 lb N fertilizer /ac. There was no response to N at the Russell site in 2000–2001 because it had previously been in alfalfa production, and soil test results indicated some 72 lb nitrate-N/acre in the 0-24" depth. The yields at the Swan River site in 2001 were very low due to drought.

In some studies plant growth parameters were measured (Figure 1). In general it was observed that N rates of 60 lb N/ac or greater maximized head length. Lodging was significantly increased at one site with high N rates, whereas the 2000-2001 Russell sites had high lodging scores even where no N was applied, probably due to the high residual N levels.

Increasing N rates generally reduced quality through higher % brown leaf content in 4 of 5 trials (Table 2), reduced Hayscan scores in 2 of 5 trials and lower grade in 1 of 3 trials (Table 3). The exception to this trend was at the 2001 Swan River site where drought limited yield and growth, and higher N rates appeared to improve quality.

Nitrogen timing

It was postulated that delaying N applications might increase timothy quality. All N applied early may promote excessive vegetative growth and shading of the lower canopy leading to greater disease and earlier leaf senescence. Later season N uptake from delayed applications may cause leaves to retain their green colour throughout harvest.

On average yields were reduced less than 10% when N application was delayed, and this reduction was significant only at Teulon in 2001 (Figure 2). Lodging was not influenced by N timing (data not shown).

The impact of delayed N on quality varied across sites. Delayed N tended to increase the % brown leaf at Swan River sites in both 2000 and 2001, whereas % brown leaf decreased at Teulon in 2001 (Table 4). Hayscan scores and grade tended to improve when N was delayed at the Teulon 2001 site (Tables 4). Averaged across sites, delayed nitrogen improved Hayscan scores and grade.

Teulon 2001 was the only site with significant yield losses with delayed N (18%), and the only site with significantly superior quality. Weather at this site was wet in the spring followed by little precipitation through mid July to August.

Nitrogen split applications

Yield response was inconsistent with split N applications, and on average there appeared to be no yield penalty to splitting N applications (Figure 3). At Teulon in 2001, the lowest yields were for the splits at 2, 6 and 8 weeks.

The quality analysis was conducted on 2-3 different dates in 2001, through the typical harvest period of late June to mid July. Quality consistently declined at the latest sampling date (i.e. increased brown leaf, reduced Hayscan scores and grade – Table 5). This was highly significant in most instances, and was of greater magnitude than that obtained through N management.

Split N applications did not impact the % brown leaf content consistently (Table 6). At Teulon in 2001 the greatest % brown leaf resulted when N was all applied early. Differences in brown leaf content were detected only at the early sampling date (July 3) at Swan River and Russell in 2001. At Swan River,

brown leaf content was highest when the N was split at 2 and 6 weeks, whereas at Russell the least brown leaf was with the 2 week split N application (Table 6).

Hayscan scores at Teulon in 2001 suggest greater quality retention with the 3 latest split applications, owing largely to quality improvement at the latest sampling date (Table 7). The lowest Hayscan score resulted when all N was applied early. The 2001 Swan River Hayscan scores were inconsistent, with highest values with all N early, or N delayed to the latest date (Table 7). The general trend across studies was a slight increase in Hayscan scores the longer the splits were delayed.

Timothy grade of the 2001 Teulon study were greatest when N was applied in later splits (Table 7), largely due to greater retention of quality at the latest date of July 17. Likewise, at Russell the July 10 grade was highest with the latest N split application.

As with the N timing study, the 2001 Teulon site had an inverse relationship between yield and quality. The split N treatments with lower yield tended to have greater quality.

Discussion

- High nitrogen rates increased yield but tended to decrease quality. Maximum yields were achieved at 80-90 lb N/ac, but the 60 lb N/ac rate suggested by the Canadian Hay Association would have restricted yield significantly in only 2 of 9 sites. Lower yields may be acceptable if quality is superior. Major improvements in quality (% brown leaf, Hayscan scores and Grade) were generally only achieved when N rates were at 0-30 lb N/ac.
- Delaying N applications reduced yields slightly and quality improvements were mixed. The one site (Teulon 2001) where delaying N improved quality (% brown leaf, Hayscan score and Grade), the yield loss was greatest (18%).
- Split N applications did not affect yield in 6 of 7 instances, and in several cases did improve quality. The one instance where later splits of N led to lower yield, quality was retained longer (Teulon 2001).
- The Teulon 2001 site produced the most consistent inverse yield and quality responses to N management. Performing economic analysis of the Teulon 2001 site indicated that improvements in quality with split application produced greater returns than the highest yield by applying all N early (Table 8).
- Delaying harvest caused more consistent and greater quality deterioration than did N management. It may be that improvements in timothy quality are produced through N management – using moderate N rates with possible split applications - in addition to earlier harvest dates.

Acknowledgements

ARDI, Covering New Ground, Ducks Unlimited, Manitoba Agriculture and Food, Sunridge Forages of Russell, Canadian Greenfield forages of Teulon

Table 1. Nitrogen rate impact on timothy yield.

N rate Lb N/ac	Yield in t/ac at individual sites								
	T99	SR99	R99	T00	SR00	R00	T01	SR01	R01
0	1.33 d	2.49	2.12	1.82 c	0.84 c	1.53	1.75 b	0.41 b	1.52 c
30		3.65	2.37				2.01 b	0.39 b	1.74 bc
40	1.87 c			2.60 ab	1.32 b	1.65			
50									
60	1.93 c	2.72	2.93	2.14 bc	1.88 a	1.78	2.57 a	0.90 ab	1.88 ab
80	2.50 a			2.76 a	2.23 a	1.94			
90		2.90	2.23				2.63 a	1.23 a	2.06 a
100				1.93 c	1.83 a	1.76			
120	2.26 ab	2.11	2.22	2.32 abc					
150		2.53	1.95	2.14 bc					
200	2.13 b								
LSD (0.05)	0.31	10%	Ns	0.47	0.41	Ns	0.34	0.52	0.29

Different letters following the values indicate significant differences at the 5% probability level.

10% indicates differences were significant at the 10% probability level. Site coding follows: T = Teulon, SR = Swan River, R = Russell, 99=1999, 00=2000, 01=2001.

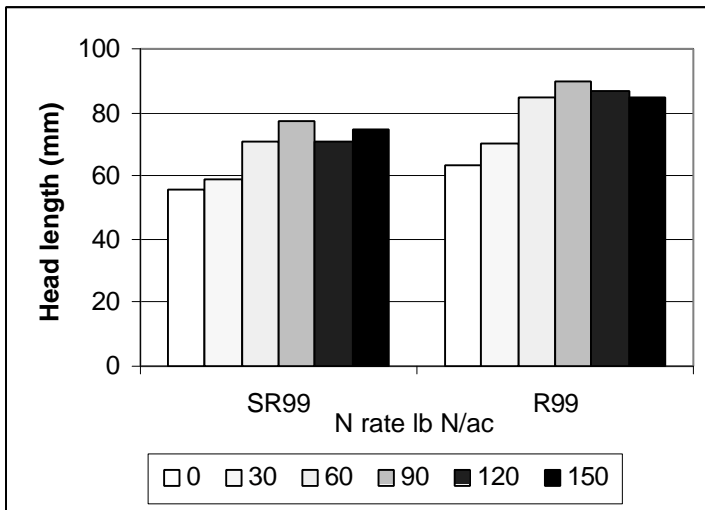


Figure 1. Head length as influenced by N rate.

Table 2. N rate impact on % brown leaf.

N rate lb N/ac	% Brown Leaf			
	T00	SR00	T01	R01
0	20	18 bc	24 b	20 c
30			27 b	26 bc
40	30	15 c		
50	25			
60	22	18 bc	35 a	32 ab
80	27	23 ab		
90			36 a	34 a
100	34	27 a		
120	35			
LSD (0.05)	10%	5.7	6.5	6.9

Different letters following the values indicate significant differences at the 5% probability level. 10% indicates differences were significant at the 10% probability level.

Table 3. N rate impact on Hayscan scores and Grade.

N rate lb N/ac	Hayscan score			Grade*
	T01	SR01	R01	T01
0	3200 a	3986	3967	2.5 a
30	2903 ab	4563	3842	2.0 b
60	2558 b	4456	3741	1.4 c
90	2640 b	4521	3531	1.7 bc
LSD (0.05)	337	10%	10%	0.43

Different letters following the values indicate significant differences at the 5% probability level. 10% indicates differences were significant at the 10% probability level.

* Grade: 1-2 = Standard, 2-3 = Choice

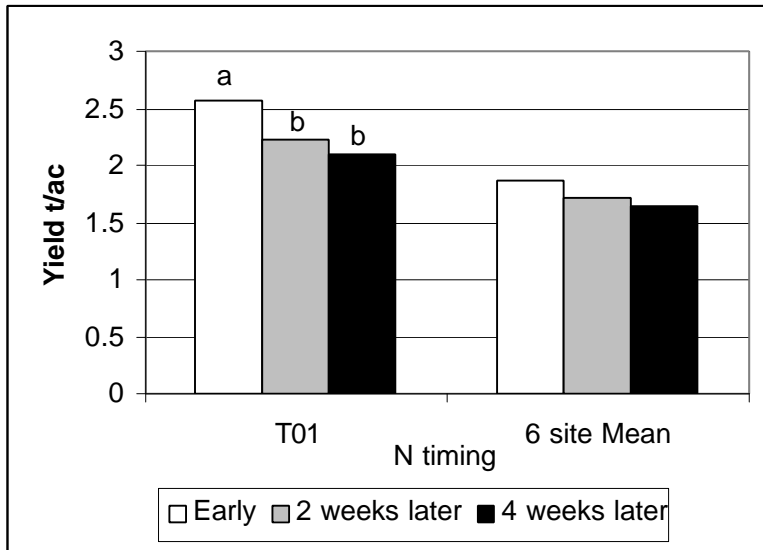


Figure 2. Impact of delayed N application on timothy yield. Different letters above columns indicate significant differences at the 5% probability level.

Table 4. Impact of delayed N application on % brown leaf, Hayscan score and Grade.

N timing	% Brown Leaf				Hayscan scores		Grade*	
	SR00	T01	SR01	5 site Mean	T01	5 site Mean	T01	3 site Mean
Early	27	35	21	29	2558 c	3757	1.4 b	2.9
2 weeks later	25	30	23	28	3016 b	3831	1.8 b	3.1
4 weeks later	37	27	27	30	3643 a	4075	2.9 a	3.6
LSD (0.05)	10%	10%	10%		413		0.9	

Different letters following the values indicate significant differences at the 5% probability level.

10% indicates differences were significant at the 10% probability level.

*Grade: 1-2 = Standard, 2-3 = Choice, 3-4 = Premium

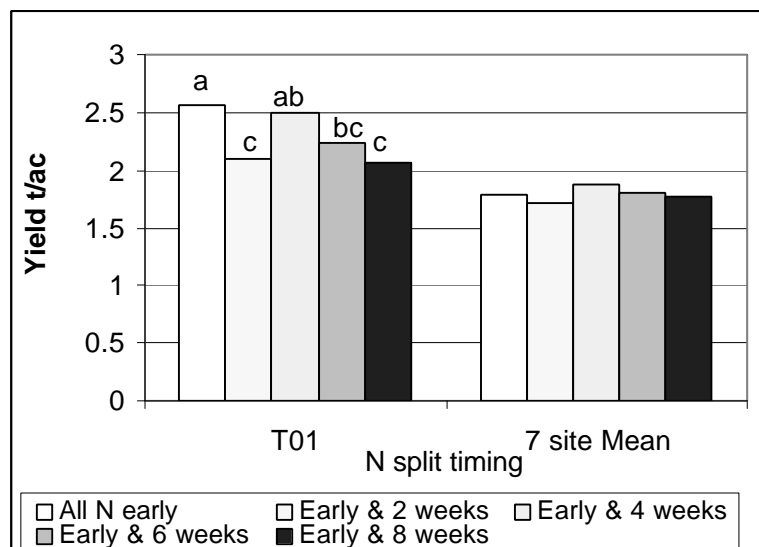


Figure 3. Impact of split N application on timothy yield.

Different letters above columns indicate significant differences at the 5% probability level.

Table 5. Impact of sampling date on timothy quality (averaged across all N split treatments).

Sampling date	% Brown leaf	Hayscan score	Grade*
June 26	26 b	2982 a	2.1
July 3	25 b	3095 a	2.1
July 17	40 a	2626 b	1.5
LSD (0.05)	5.3	310	10%

Different letters following the values indicate significant differences at the 5% probability level. 10% indicates differences were significant at the 10% probability level.

*Grade: 1-2 = Standard, 2-3 = Choice

Table 6. Impact of split N application on % brown leaf.

N timing	% Brown leaf			
	Across all sample dates		July 3	
	T01	5 site Mean	SR01	R01
All N early	35	29	19 c	26 a
Early & 2 weeks	32	28	34 a	16 b
Early & 4 weeks	29	29	25 bc	26 a
Early & 6 weeks	30	31	32 ab	28 a
Early & 8 weeks	28	28	23 c	30 a
LSD (0.05)	10%		8.9	7.0

Different letters following the values indicate significant differences at the 5% probability level. 10% indicates differences were significant at the 10% probability level.

Table 7. Impact of split N application on Hayscan score and Grade.

N timing	Hayscan score				Grade*			
	Across all sample dates			July 17	Across all sample dates		July 17	July 10
	T01	SR01	5 site Mean	T01	T01	3 site Mean	T01	R01
All N early	2558 c	4466 a	3804	2361	1.40 c	2.93	1.00 b	1.75 b
Early & 2 weeks	2796 b	4208abc	3878	2502	1.70 bc	3.10	1.25 b	1.75 b
Early & 4 weeks	3107 a	4159bc	3917	2610	2.20 a	3.20	1.25 b	2.00 b
Early & 6 weeks	3063 a	3996c	3951	2598	2.20 a	3.10	1.75 a	2.00 b
Early & 8 weeks	2982 ab	4408 ab	4047	2942	1.90 ab	3.33	2.00 a	3.50 a
LSD (0.05)	232	271		10%	0.36		0.50	0.87

Different letters following the values indicate significant differences at the 5% probability level. 10% indicates differences were significant at the 10% probability level.

*Grade: 1-2 = Standard, 2-3 = Choice, 3-4 = Premium

Table 8. Economic evaluation of split N applications on yield, quality and return (using Teulon 2001 data).

Sampling date	Returns			Costs			Gross margin
	Yield	Grade	Gross return	N fertilizer	Application	Total	
All N early	2.57 a	Standard	\$231	\$21	\$4	\$25	\$206
Early & 2 weeks	2.09 c	Standard	\$188	\$21	\$8	\$29	\$159
Early & 4 weeks	2.50 ab	Choice	\$288	\$21	\$8	\$29	\$259
Early & 6 weeks	2.23 bc	Choice	\$256	\$21	\$8	\$29	\$227
Early & 8 weeks	2.06 c	Standard	\$185	\$21	\$8	\$29	\$156

Costs = N at 60 lb N/ac, N fertilizer at \$0.35/lb N, N application = \$4/ac

Returns: Standard quality = \$90/t, Choice = \$115/t

References

Jefferson, P.G., B. E. Coulman and G.A. Kielly. 2001. Production and quality of irrigated timothy hay in Saskatchewan for export hay markets. *Agron. J.* 93:910-917.

Timothy Production Handbook. 1999. Canadian Hay Association.