Nutrient Requirements of Mixed Forages

Project # 95E108

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Background

A gradual decrease in the percent legume of mixed forages has been accepted by many farmers as a normal symptom of an aging sward. Efforts to rejuvenate swards by aerating and sod-seeding has resulted in limited success. Workdown and re-establishment of the sward may not be the best option on soils where topography or soil texture may predispose the soil to erosion or where stoniness greatly increases the cost of tillage. Re-establishment of the sward also interrupts the supply of forage which must be compensated for by purchases of hay or temporarily reducing cattle inventory. A balanced soil fertility program along with timely harvest management may be instrumental in maintaining the legume component of the sward and hence maintain yield over an extended period of time. With the potential for strength in the cereal and oilseed markets to decrease the land base used for forage production, strategies to increase forage yields must be explored.

Objectives

Component A

- identify the fertilizer regimes necessary to maximize yield of mixed grass-legume swards.
- determine the effect of nitrogen and phosphorus applied alone and in combinations on the composition of mixed forage swards.
- determine the effect of nitrogen and phosphorus on forage quality.

Component B

- compare harvesting methods (fodder and simulated grazing) on yield, composition and quality of the sward at different levels of fertilization

Progress to Date

Trials to assess the nutrient requirements of mixed forages were established in May 1995 near Calmar (NE 20-48-26-4) on an eluviated Black Chernozemic soil and at Lac La Biche (SW 29-67-12-4) on an Orthic Gray Luvisol. At Calmar, the trial was established on a two year old stand of alfalfa (Medicago Sativa) and orchardgrass (Dactylis glomerata) while the stand at Lac La Biche was a three year old mixture of alfalfa (Medicago sativa cv. Grimm) and timothy (Phleum pratense cv. Climax). The fertilizer treatments listed in Table 1 are applied on an annual basis.

Component A

Fertilizer was broadcast on May 1 at Calmar and May 8 at Lac La Biche. Urea (46-0-0) and Triple Super Phosphate (0-45-0) were used as the sources of nitrogen and phosphate respectively. Potassium Sulphate (0-0-50-17) was used to supply 88 kg ha $^{-1}$ and 30 kg ha $^{-1}$ of potash and sulphur respectively. Nitrogen and phosphate were applied in a factorial design to assess the effect of all combinations on yield and percent composition of the sward. Plots were harvested at Calmar on July 8 and September 12 while the trial at Lac La Biche was harvested July 3 and September 16.

Table 1. List of Treatments

Treatment #	Nitrogen (kg/ha)	Phosphorus (kg/ha)
1	0	0
2	0	10
3	0	20
4	0	30
5	0	40
6	20	0
7	20	10
8	20	20
9	20	30
10	20	40
11	40	0
12	40	10
13	40	20
14	40	30
15	40	40
16	60	0
17	60	10
18	60	20
19	60	30
20	60	40
21	80	0
22	80	10
23	80	20
24	80	30
25	80	40

Results and Discussion

Statictical analysis was done using STATISTIX Version 4.1. The probability (P) values for the effect of N, P_2O_5 and their interaction on yield and quality of forage grown in Component A at Calmar and Lac La Biche are shown in Table 2.

Table 2. Analysis of Variance Probability Table (Component A, 1996)

	(Calmar)			
	Source	First Cut (P)	Second Cut (P)	Total (P)
Yield	N	0.2487	0.1761	0.1183
	P	0.2520	0.0787	0.0566
	NXP	0.4049	0.3915	0.8491
Protein	N	0.0079	0.0016	
	P	0.3244	0.9212	
	NXP	0.2019	0.2948	
ADF	N	0.2099	0.0368	
	P	0.6758	0.7623	
	NXP	0.0561	0.4452	
NDF	N	0.0000	0.0011	
	P	0.3451	0.8993	
	NXP	0.0962	0.1652	
% Legume	N	0.0000	0.0004	
	P	0.6442	0.7626	
	NXP	0.1250	0.4294	
Alfalfa Yield	N	0.0008	0.1986	0.0011
	P	0.3648	0.1399	0.1994
	NXP	0.1004	0.3527	0.4288

	(Lac La Biche)			
	Source	First Cut (P)	Second Cut (P)	Total (P)
Yield	N	0.0000	0.2129	0.0000
	P	0.9412	0.5769	0.6263
	NXP	0.6262	0.1388	0.2535
Protein	N	0.0063	0.0001	
	P	0.2435	0.0287	
	NXP	0.3564	0.7829	
ADF	N	0.0003	0.1394	
	P	0.3796	0.0174	
	NXP	0.0771	0.6421	
NDF	N	0.0000	0.0001	
	P	0.3110	0.1358	
	NXP	0.1107	0.5630	
% Legume	N	0.0000	0.0244	
	P	0.0917	0.0036	
	NXP	0.2593	0.8735	
Alfalfa Yield	N	0.2290	0.0119	0.0110
	P	0.2102	0.2443	0.0814
	NXP	0.1492	0.4464	0.2807

A confidence level of 95% ($P<0.05$) was used to determine significance of the treatments. P values less than 0.05 indicate there is less than a 5% chance differences in yield or quality are due to an effect other than the treatment applied and hence the treatment had a significant effect on the parameter measured. For example, at Calmar in the second cut, the effect of nitrogen on percent ADF is significant since the "P" value is 0.0368 whereas the effect of phosphorus is not significant since the P value is 0.7623.

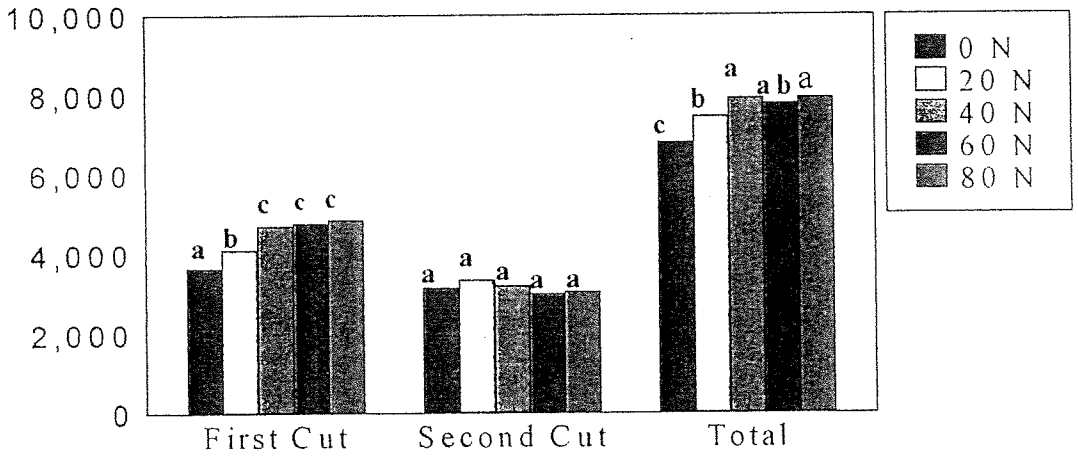
1. Effect of nitrogen

A. Yield

Nitrogen had no significant effect on yield in either the first cut (P=0.2487), the second cut (P=0.1761) or in total yield (P=0.1183) at Calmar. Total yield ranged from 6069 kg ha^{-1} at 0 N and 0 P_2O_5 to 7592 kg ha-1 at 40 N and 40 P_2O_5. Early in the growing season, nitrogen increased grass growth however this difference was not visually evident when the first cut was taken. It is speculated that with increasing temperatures later in the growing season, nitrogen fixation provided adequate nitrogen for alfalfa development.

At Lac La Biche nitrogen significantly increased yield in the first cut (P=0.0000) but had no effect on yield in the second cut (P=0.2129). The effect of nitrogen on yield in the first cut carried through to nitrogen significantly increasing total yield (P=0.0000). The effect of nitrogen on yield at Lac La Biche is shown in Figure 1.

Figure 1. Effect of Nitrogen on Yield of Mixed Forage Grown at Lac La Biche (Component A, 1996)



There was a significant increase in yield of the first cut to each increment of nitrogen up to 40 kg ha^{-1} and no further increase to higher rates of nitrogen. Yield in the first cut ranged from 3649 kg ha^{-1} at 0 N to 4857 kg ha^{-1} at 80 N. Total yield increased from 6798 kg ha^{-1} at 0 N to 7917 kg ha^{-1} at 80 N.

The effect of nitrogen on yield of alfalfa was assessed by multiplying yield for each cut by percent alfalfa. In the first cut at Calmar, nitrogen decreased yield of alfalfa from 3065 kg ha^{-1} at 0 N to 2322 kg ha^{-1} at 80 N (data not shown) and also significantly reduced total yield (cuts 1 and 2 combined) of alfalfa from 5214 kg ha^{-1} at 0 N to 4385 kg ha^{-1} at 80 N. Yield of alfalfa from the two cuts decreased from 5214 kg ha^{-1} at 0 N to 4385 kg ha^{-1} at 80 N. At Lac La Biche nitrogen had no effect on yield of alfalfa in the first cut however yield of alfalfa decreased from 2667 kg ha^{-1} at 0 N to 2430 kg ha^{-1} at 80 N. Total yield of alfalfa for the two cuts decreased from 5305 kg ha^{-1} at 0 N to 4932 kg ha^{-1} at 80 N.

B. Composition

Nitrogen significantly reduced percent alfalfa (Table 2) in both cuts at both locations (P=0.0000 and P=0.0004 in the first and second cuts at Calmar and P=0.0000 and P=0.0244 in the first and second cuts at Lac La Biche respectively). The effect of nitrogen on composition is shown in Table 3.

Table 3. Effect of Nitrogen on Percent Alfalfa in Mixed Forage Swards (Component A, 1996)

	(Calmar)		(Lac La Biche)	
N Applied	First Cut	Second Cut	First Cut	Second Cut
0	78 a	84 a	72 a	84 ab
20	70 b	81 ab	64 b	87 a
40	63 c	78 bc	55 c	80 bc
60	59 cd	76 c	49 d	78 c
80	55 d	74 c	51 cd	80 bc

Within columns, means followed by different letters are significantly different at P= 0.05

At Calmar alfalfa decreased from 78% at 0 N to 55% at 80 N in the first cut while at Lac La Biche alfalfa decreased from 72% at 0 N to 51% at 80 N. In the second cut alfalfa decreased from 84% at 0N to 74% at 80 N at Calmar while at Lac La Biche alfalfa decreased from 84% at 0 N to 80% at 80 N.

The variation in percent alfalfa was greater in the first cut as compared to the second cut at both locations. Cool and wet conditions in spring and early summer at both locations resulted in a reduced rate of nitrogen fixation by alfalfa. As a result fertilizer nitrogen stimulated growth of the grass component of the sward. Nitrogen depletion by crop growth during the first growth period and increasing soil temperatures in summer stimulating the nitrogen fixation process resulted in the alfalfa being dominant in the sward during the second growth period.

C. Quality

The effect of nitrogen on forage quality is shown in Table 4. Forage quality parameters measured included protein, acid detergent fibre (ADF) and neutral detergent fibre (NDF). ADF is a measure of digestibility while NDF is a predictor of forage intake. As ADF increases, digestibilty decreases and hence feed value decreases. As NDF increases digestibility decreases and hence intake decreases since the plant material remains in the rumen for a longer period of time.

Table 4. Effect of Nitrogen on Forage Quality (Component A, 1996)

	(Calmar)					
	First Cut			Second Cut		
N Applied	Protein	ADF	NDF	Protein	ADF	NDF
0	20.2 a	34.4 a	43.8 c	18.4 a	34.2 ab	43.1 b
20	19.1 b	35.5 a	46.6 b	18.0 ab	35.1 a	43.6 b
40	19.0 b	35.1 a	47.4 ab	18.4 a	33.6 b	43.0 b
60	19.1 b	32.6 a	47.9 ab	17.4 bc	35.3 a	45.5 a
80	18.9 b	35.7 a	48.6 a	17.3 c	34.6 ab	45.9 a
Critical Value for Comparison	0.7	1.2	1.6	0.7	1.2	1.7

	(Lac La Biche)					
	First Cut			Second Cut		
N Applied	Protein	ADF	NDF	Protein	ADF	NDF
0	15.0 a	35.2 c	47.2 c	18.2 a	36.9 a	43.3 c
20	14.9 a	36.2 bc	49.9 b	17.7 ab	37.8 a	44.9 b
40	14.6 b	38.5 a	54.6 a	17.5 b	37.1 a	44.9 b
60	14.4 a	37.5 ab	52.8 a	17.2 b	37.4 a	45.6 ab
80	14.6 a	37.7 a	53.9 a	16.4 c	38.2 a	46.6 a
Critical Value for Comparison	1.0	1.5	2.1	0.7	1.7	1.3

Within columns, means followed by different letters are significantly different at P= 0.05

In the first cut at Calmar, nitrogen decreased protein from 20.2% at 0 N to 18.9% at 80 N while NDF increased from 43.8% at 0 N to 48.6% at 80 N. In the second cut percent protein decreased from 18.4% at 0 N to 17.3% at 80 N and ADF decreased from 34.2% at 0 N to 33.6% at 40 N and then increased to 34.6% at 80 N. NDF increased from 43.1% at 0 N to 45.9% at 80 N.

In the first cut at Lac La Biche, nitrogen decreased protein from 15.0% at 0 N to 14.6% at 80 N. ADF increased from 35.2% at 0 N to 38.5% at 40 N and then decreased to 37.5% and 37.7% at 60 N and 80 N respectively however the decrease at the higher nitrogen rates was not significant. Nitrogen increased NDF from 47.2% at 0 N to 54.6% at 40 N

and then decreased to 52.8% and 53.9% at 60 N and 80 N respectively; the decrease at 60 N and 80 N was not significantly different from 40 N. In the second cut protein decreased from 18.2% at 0 N to 16.4% at 80 N and NDF increased from 43.3% at 0 N to 46.6% at 80 N.

2. Effect of phosphorus

A. Yield

There was no significant effect of phosphorus on yield of forage or yield of alfalfa at either location. There was a trend for phosphorus to increase yield of the second cut (P=0.0787) and total yield (P=0.0566) at Calmar (Table 2).

B. Composition

Phosphorus had no significant effect on percent alfalfa in either cut at Calmar however at Lac La Biche there was a trend for phosphorus to increase percent alfalfa in the first cut (P=0.0917). In the second cut percent alfalfa decreased from 83.2% at 0 P_2O_5 to 74.6 at 40 P_2O_5. This trend is unexplained (data not shown).

C. Quality

Phosphorus had no significant effect on any forage quality parameters.

Component B

Trials were established adjacent to Component A at both locations to determine the effect of method of harvesting on yield and composition of the sward. Plots were harvested by simulated grazing (clipping) when the alfalfa was 20 cm (8 in). Other elements of the experimental design were identical to those of Component A to facilitate the comparison of method of harvest on yield, composition and quality of the forage. Component B at Calmar was harvested on June 21, August 9 and September 9. At Lac La Biche, component B was harvested on June 14, July 25 and September 16.

Table 5. List of Treatments

Treatment #	Nitrogen (kg/ha)	Phosphorus (kg/ha)
1	0	10
2	0	30
3	20	10
4	20	30
5	40	10
6	40	30
7	80	10
8	80	30

Results and Discussion

The probability (P) values for the effect of N, P_2O_5 and their interaction on yield at Calmar and Lac La Biche is shown in Table 6.

Table 6. Analysis of Variance Probability Table (Component B, 1996)

	(Calmar)				
	Source	First Cut (P)	Second Cut (P)	Third Cut (P)	Total (P)
Yield	N	0.0000	0.8373	0.0161	0.0021
	P	0.9407	0.3855	0.5929	0.4023
	NXP	0.7699	0.9671	0.6041	0.9087
% Legume	N	0.0000	0.0065	0.4057	
	P	0.0424	0.5597	0.5856	
	NXP	0.8110	0.0579	0.3427	
Alfalfa Yield	N	0.0114	0.0240	0.0365	0.0005
	P	0.0620	0.7966	0.9969	0.2553
	NXP	0.8670	0.2496	0.3925	0.1389

	(Lac La Biche)				
	Source	First Cut (P)	Second Cut (P)	Third Cut (P)	Total (P)
Yield	N	0.0001	0.1496	0.9063	0.1333
	P	0.7742	0.9590	0.2223	0.3251
	NXP	0.5563	0.7743	0.2711	0.2350
% Legume	N	0.0012	0.0002	0.9031	
	P	0.2453	0.0374	0.6951	
	NXP	0.4638	0.4409	0.0596	
Alfalfa Yield	N	0.9693	0.0228	0.8567	0.3624
	P	0.3267	0.5367	0.1948	0.8856
	NXP	0.4622	0.5867	0.2730	0.1838

Figure 2. Effect of Nitrogen on Yield of an Alfalfa-Orchardgrass Mixed Forage Sward Harvested by Simulated Grazing (Calmar B, 1996)

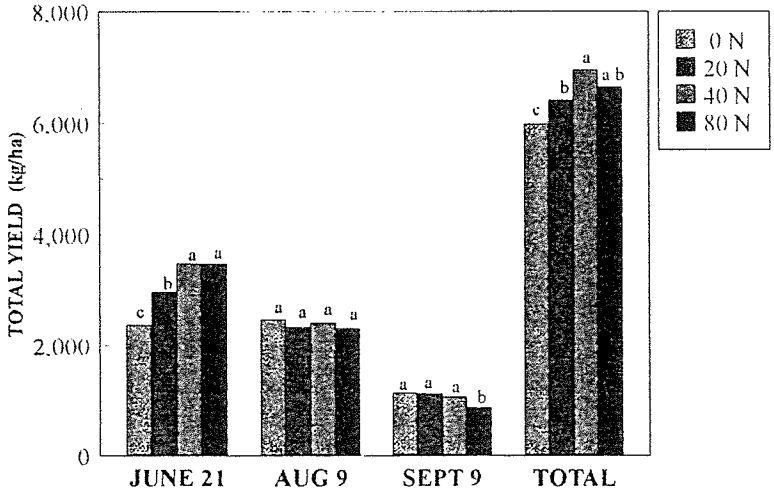
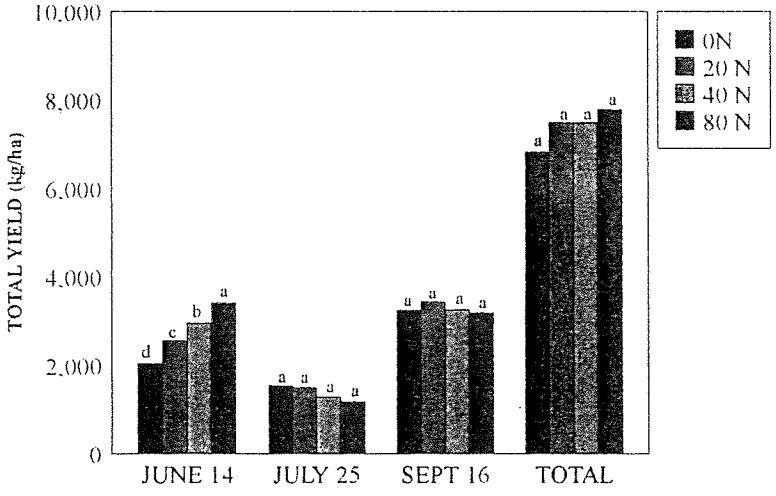


Figure 3. Effect of Nitrogen on Yield of an Alfalfa-Timothy Mixed Sward Harvested by Simulated Grazing (Lac La Biche B, 1996)



1. Effect of nitrogen

A. Yield

The effect of nitrogen on yield of forage harvested by simulated grazing at Calmar shown in Figure 2 and in Figure 3 for Lac La Biche. At Calmar in the first growth period nitrogen significantly increased yield from 2367 kg ha^{-1} at 0 N to 3471 kg ha^{-1} at 40 N and 80 N. At Lac La Biche, nitrogen significantly increased yield from 2043 kg ha^{-1} at 0 N to 3409 kg ha^{-1} at 80 N. Nitrogen had no effect on yield in the second and third growth periods at either location. A significant response to nitrogen in the first cuts carried through to a significant response in total yield at Calmar but nitrogen had no effect on total yield at Lac La Biche.

These results showed that nitrogen increased yield at both locations. This suggests that even in a forage sward dominated by alfalfa nitrogen deficiency may still limit growth in spring and early summer when cool and wet conditions may limit nitrogen fixation by alfalfa.

Research at the Agriculture and Agri-Food Canada research station at Beaverlodge has shown the nitrogen fixation is temperature sensitive and a soil temperature of 10 °C is necessary for nitrogen fixation to proceed. Similar results were obtained in 1995 which was also characterized by cool spring temperatures. In later growth periods, no response to nitrogen was obtained which suggests the nitrogen fixation process was meeting crop requirements or that applied nitrogen was depleted by crop uptake earlier in the growing season.

Figure 4. Effect of Nitrogen on Percent Alfalfa in an Alfalfa-Orchardgrass Mixed Forage Sward Harvested by Simulated Grazing
(Calmar B, 1996)

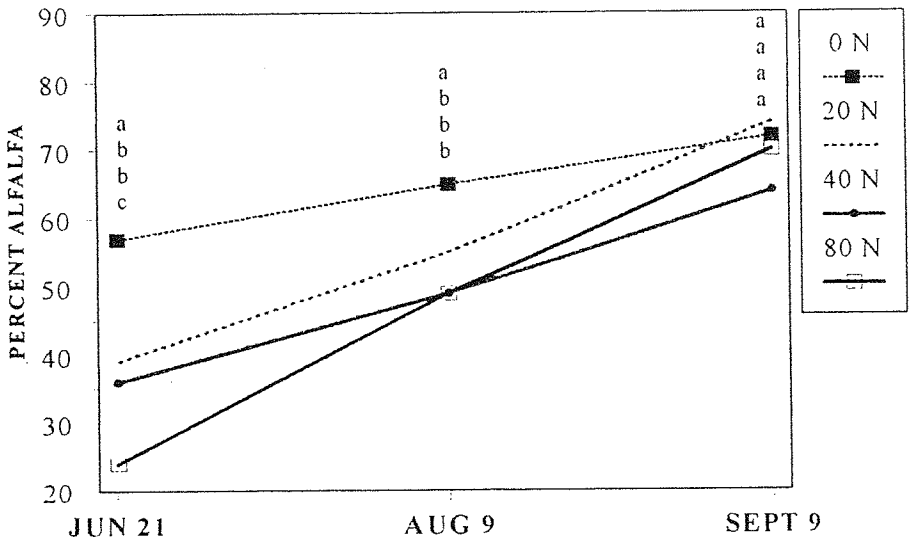
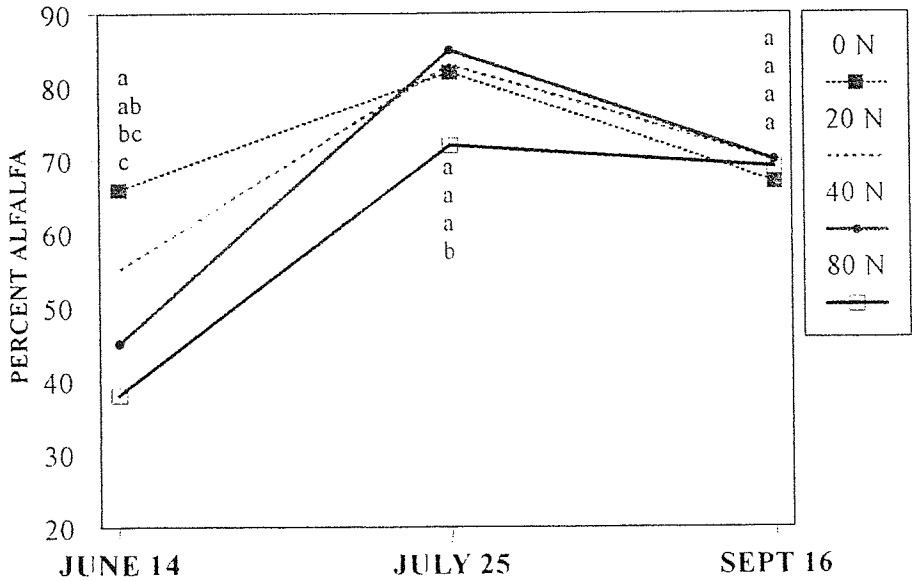


Figure 5. Effect of Nitrogen on Percent Alfalfa in an Alfalfa-Timothy Mixed Forage Sward Harvested by Simulated Grazing
(Lac La Biche B, 1996)



B. Composition

The effect of nitrogen on percent alfalfa in a mixed forage sward is shown in Figure 4 at Calmar and Figure 5 at Lac La Biche. At Calmar, nitrogen decreased alfalfa from 57% at 0 N to 24% at 80 N in the first growth period. In the second growth period, percent alfalfa decreased from 65% at 0 N to 49% in the 40 N and 80 N treatments. In the third growth period, there were no significant effect of nitrogen on percent alfalfa.

At Lac La Biche percent alfalfa decreased from 66% at 0 N to 38% at 80 N in the first growth period. In the second growth period there was no effect from nitrogen at rates up to 60 N however percent alfalfa at 80 N was significantly lower than percent alfalfa at the lower nitrogen rates. There was no effect from nitrogen on percent alfalfa in the third growth period.

Because of increasing presence of white clover in the sward at Calmar, the legume component was divided into alfalfa and white clover in the second and third growth periods. In the second growth period, percent clover was 12.8%, 18.0%, 15.4% and 8.6% at the 0, 20, 40 and 80 N rates respectively (data not shown). In the third cut, percent clover was 10.0%, 7.9%, 9.2% and 3.8% at the 0, 20, 40 and 80 N rates respectively. White Clover will tolerate heavy and continuous grazing and may become dominant in the stand. White clover was not observed in component A or in the surrounding field which was harvested in a two-cut management system.

2. Effect of phosphorus

A. Yield

Phosphorus had no effect on yield at either location. It is not anticipated that application of phosphorus would increase forage yields in the early stages of the project. The perennial nature of the root system provides the sward with the opportunity to access residual phosphorus applied to cereal and oilseed crops previously grown in the rotation. It is speculated that as residual phosphorus is depleted from the soil, crop response will occur in the later stages of the trial. It is further speculated that phosphorus fertilization will be instrumental in maintaining the legume component of mixed swards.

B. Composition

At Calmar, phosphorus significantly increased percent alfalfa in the first growth period (data not shown). Percent alfalfa increased from 35.8% at 10 P_2O_5 to 42.2% at 30 P_2O_5.

In the second growth period at Lac La Biche, phosphorus increased percent alfalfa from 78.8% at 10 P_2O_5 to 82.6% at 30 P_2O_5. Differences in the response patterns between the two sites may be due to different weather conditions and previous management of the sward. Early growing season conditions were somewhat drier at Lac La Biche than at

Calmar. Drought for several years prior to establishment of the trial resulted in relatively low yields at Lac La Biche which may have minimized nutrient depletion by previous growth.

Preliminary Observations

1. Nitrogen may significantly increase yield of mixed forage swards particularly in years when cool spring and early summer temperatures may limit the nitrogen fixation process in legumes. Under these conditions growth of both the legume and grass components of the sward may be limited by nitrogen deficiency.

2. Nitrogen enhanced growth of the grass component of the sward and consequently decreased percent alfalfa in the sward at both locations and in both cuts in Component A.

3. Phosphorus generally had no effect on yield or composition of the sward. In the opinion of the author, phosphorus may play an important role in maintaining the legume component of the sward as the sward ages. Continued monitoring of the trials is essential to understand the role of phosphorus in nutrition of legumes.

4. In the simulated grazing trial (Component B), a small application of nitrogen increased yield at both locations. A rigorous harvesting regime in 1995 may have reduced the yield of alfalfa in 1996 at Calmar.

5. White clover which is well adapted grazing conditions continued to become more dominant in the sward in Component B.

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