AB-13

Nutrient Requirements

Of

Mixed Forages

(1997/98 Interim Year Report)

Project #95E108

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Background

A gradual decrease in the percent legume in 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).

Component A

Fertilizer was broadcast on May 8 at Calmar and May 14 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. A list of treatments is displayed in Table 1. Plots were harvested at Calmar on July 3, August 7 and September 22 while the trial at Lac La Biche was harvested June 25 and September 10.

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

Statistical 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, 1997)

(Calmar)					
	Source	First Cut (P)	Second Cut (P)	Third Cut (P)	Total (P)
Yield	N	0.0099*	0.3864	0.4189	0.1594
	P	0.4267	0.4089	0.6229	0.2461
	NXP	0.2821	0.8727	0.4278	0.6078
% Legume	N	0.0479*	0.0817		
	P	0.8954	0.7783		
	NXP	0.4517	0.6753		
Alfalfa Yield	N	0.5809	0.8023		0.5017
	P	0.8557	0.9148		0.9524
	NXP	0.3157	0.9518		0.5406

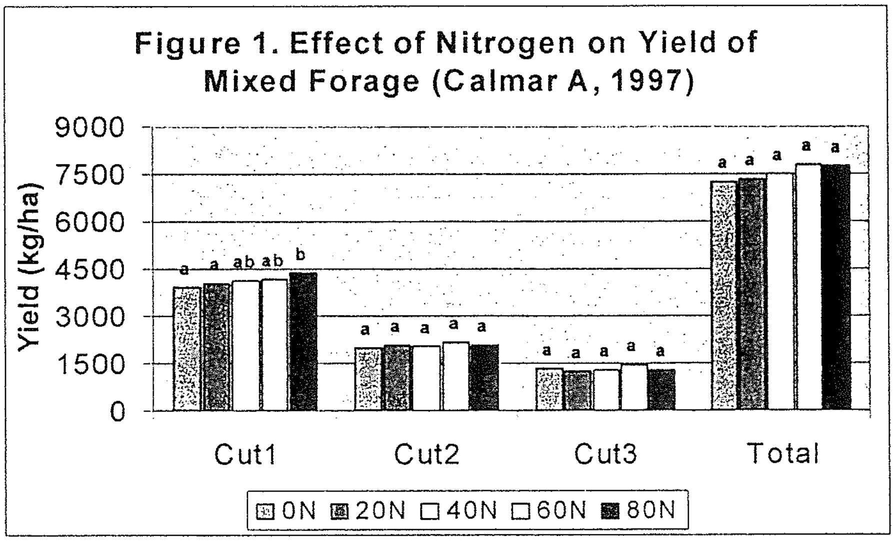
(Lac La Biche)				
	Source	First Cut (P)	Second Cut (P)	Total (P)
Yield	N	0.3500	0.1572	0.7061
	P	0.3555	0.6741	0.3086
	NXP	0.8143	0.5515	0.4374
% Legume	N	0.1274	0.0065*	
	P	0.0128*	0.1005	
	NXP	0.1293	0.2176	
Alfalfa Yield	N	0.1355	0.7857	0.2047
	P	0.0190*	0.3226	0.0557
	NXP	0.0973	0.3067	0.0928

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 first cut, the effect of nitrogen on yield is significant since the "P" value is 0.0099 whereas the effect of phosphorus is not significant because the P value is 0.4267.

Effect of Nitrogen

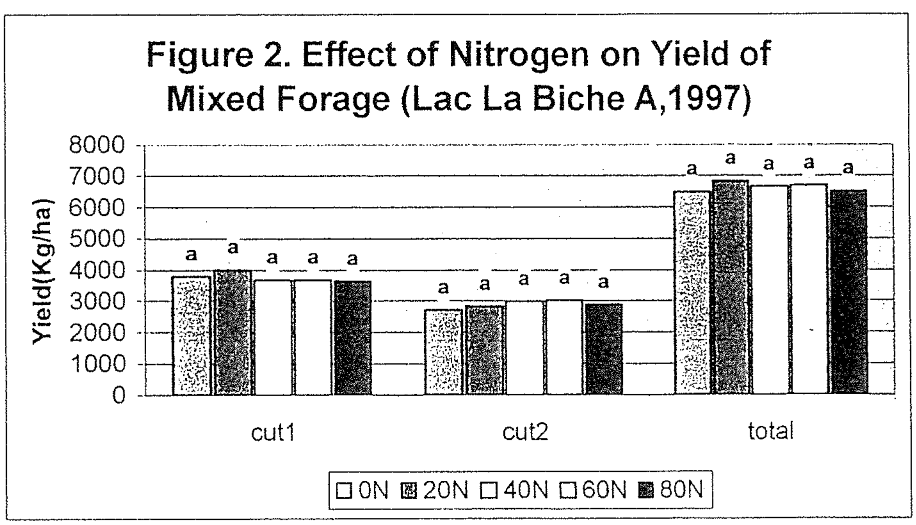
A. Yield

At Calmar, nitrogen had a significant effect on yield of mixed forage in first cut (P=0.0099) however, there was no effect in the second (P=0.3864) and third (P=0.4189) cuts or in total yield (P=0.1594). The effect of nitrogen averaged over five rates of phosphate is presented in Figure 1. Yield ranged from 3919 kg ha^{-1} at 0 N to 4364 kg ha^{-1} at 80 N. The effect of nitrogen on yield of the first cut was also observed in 1995. It is the author's opinion nitrogen promoted growth of the grass component early in the growing season when low soil temperatures limited nitrogen fixation by the alfalfa component of the sward. As temperatures increased later in the growing season, nitrogen fixation provided adequate nitrogen for optimal growth of the sward and therefore nitrogen had no effect on yield in the second cut. An alternate explanation for no effect of nitrogen on yield of the second cut may be due to nitrogen depletion by growth harvested in the first cut.



* Values are averaged across all P rates

At Lac La Biche, nitrogen had no significant effect on yield of mixed forage either in the first cut (P=0.3500) nor the second cut (P=0.1572). The effect of nitrogen on yield of the first and second cuts and on total yield is shown in Figure 2. In 1995 and 1996 nitrogen increased yield of the first cut but had no effect on yield of the second cut.



Three Year Yield Summary

The effect of nitrogen on yield of the first cut at Calmar and Lac La Biche is shown in Table 3 and Table 4 respectively. As previously reported, nitrogen increased yield in 1995 and 1997 at Calmar and in 1995 and 1996 at Lac La Biche. A response to nitrogen may be expected when environmental conditions such as temperature or soil moisture limits growth of alfalfa and consequently reduces the nitrogen fixation process. Farmers may consider a small application of nitrogen in the range of 20 kg ha^{-1} under these conditions if optimal forage production is desired.

Table 3. Effect of Nitrogen on First Cut Yields of Mixed Forage (Calmar A)

Rate of N	1995	1996	1997
	Kg/ha		
0N	3736 a	3934 a	3918 a
20N	3972 b	3894 a	4032 a
40N	4064 b	4208 a	4129 ab
60N	4168 b	4286 a	4148 ab
80N	4194 b	4226 a	4363 b

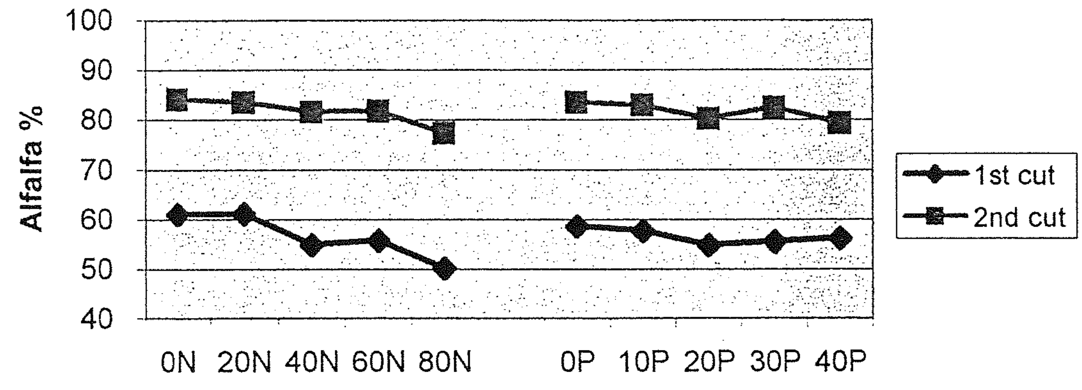
Table 4. Effect of Nitrogen on First Cut Yields of Mixed Forage (Lac La Biche A)

Rate of N	1995	1996	1997
	Kg/ha		
0N	3539 a	3649 a	3785 a
20N	3904 b	4105 b	3993 a
40N	4293 b	4705 c	3662 a
60N	4333 b	4771 c	3669 a
80N	3946 b	4856 c	3621 a

B. Composition

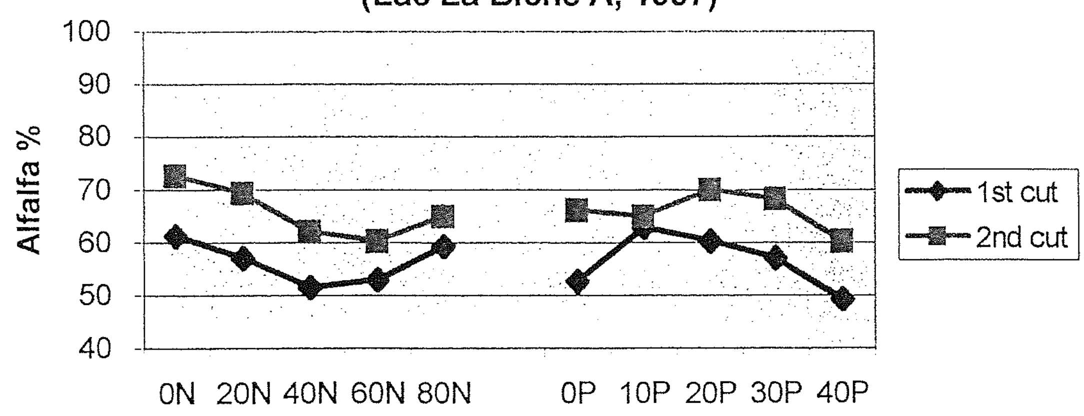
Nitrogen significantly (Table 2) reduced percent alfalfa in the first cut (P=0.0479) but had no effect in the second cut (P=0.0817) at Calmar. The effect of nitrogen on composition at Calmar is shown in Figure 3. In the first cut, alfalfa decreased from 63% at 0 N to 52% at 80 N in the first cut. In the second cut percent alfalfa decreased from 86% at 0 N to 79% at 80 N. There was no significant effect from nitrogen or phosphate in the second cut.

Figure 3. Effect of Nitrogen and Phosphorus on Percent Alfalfa in Mixed a Forage Sward (Calmar A, 1997)

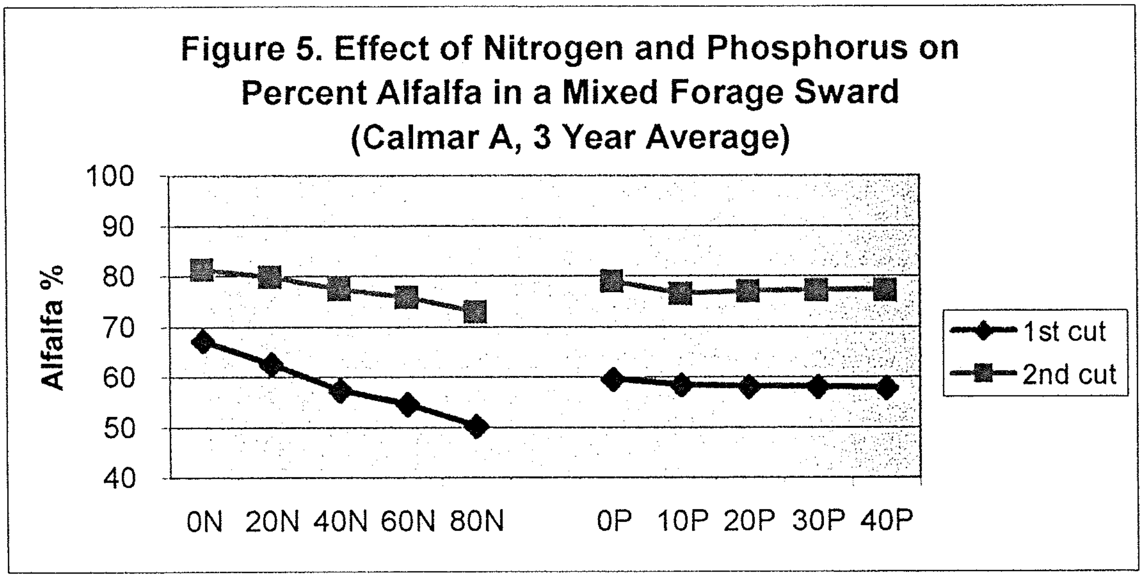


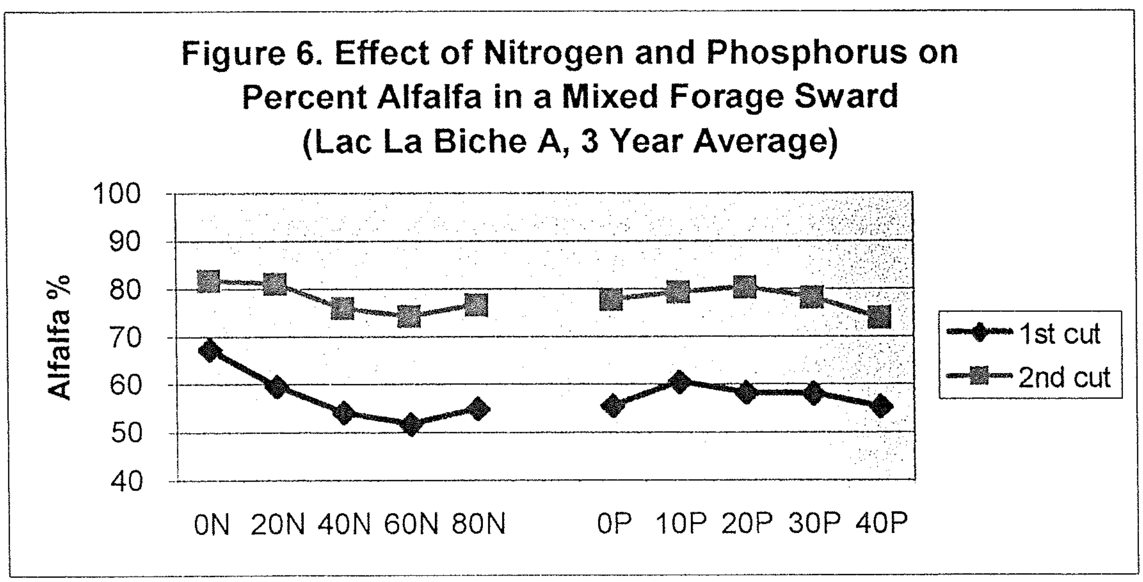
The effect of nitrogen and phosphorus on percent alfalfa is shown in Figure 4. Nitrogen had a significant effect on percent alfalfa in the second cut (P=0.0065). Percent alfalfa decreased from 73% at 0 N to 60% at 60 N and then increased to 65% at 80 N however the increase from the last increment of nitrogen was not significant. Phosphorus had a significant effect on percent alfalfa (P=0.0128) in the first cut. Percent alfalfa at 0 P_2O_5 was 53%, 63% at 30 P_2O_5 and then decreased to 49% at 40 P_2O_5. The decrease in percent alfalfa higher from the last increment of phosphorus was not significant.

Figure 4. Effect of Nitrogen and Phosphorus on Percent Alfalfa in a Mixed Forage Sward (Lac La Biche A, 1997)



The effect of nitrogen and phosphorus on percent alfalfa at Calmar and Lac La Biche averaged over 3 years is presented in Figure 5 and Figure 6 respectively. These results show nitrogen decreased percent alfalfa from 68% at 0 N to 50% at 80 N in the first cut at Calmar and from 67 % at 0 N to 53% at 60 N at Lac La Biche. The effect in the second cut was not as dramatic. There was no consistent trend with phosphorus.





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. Fertilizer was broadcast on May 8 at Calmar and May 14 at Lac La Biche. 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. A list of treatments is displayed in table 5. Component B at Calmar was harvested on June 17, July 28 and September 22. At Lac La Biche, component B was harvested on June 26, July 29 and September 10.

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 are shown in Table 6.

Table 6. Analysis of Variance Probability Table (Component B, 1997)

	(Calmar)				
	Source	**First Cut (P)**	**Second Cut (P)**	**Third Cut (P)**	**Total (P)**
Yield	**N**	0.3239	0.4349	0.0538	0.3312
	P	0.7793	0.0383*	0.0767	0.0374*
	NXP	0.2385	0.7178	0.3055	0.2710
% Legume	**N**	0.0417*	0.4151		
	P	0.7001	0.6336		
	NXP	0.2124	0.1054		
Alfalfa Yield	**N**	0.1929	0.2573		0.1867
	P	0.7552	0.3147		0.6332
	NXP	0.1179	0.0893		0.0585

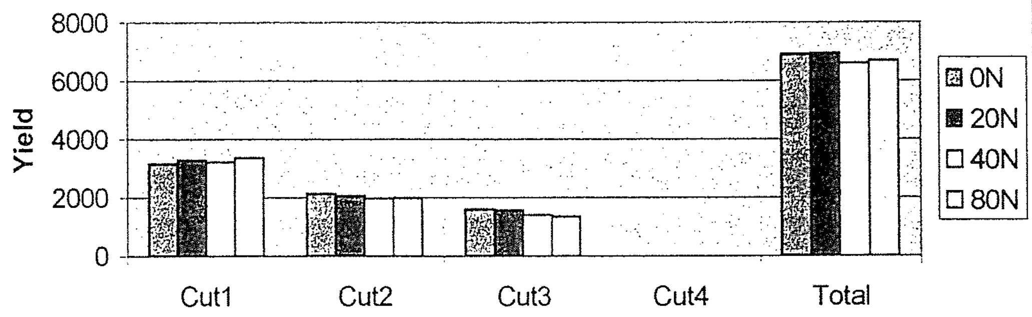
	(Lac La Biche)				
	Source	**First Cut (P)**	**Second Cut (P)**	**Third Cut (P)**	**Total (P)**
Yield	**N**	0.0866	0.0052*	0.2538	0.4507
	P	0.2842	0.1583	0.7968	0.1740
	NXP	0.6899	0.6922	0.2840	0.6899
% Legume	**N**	0.0040*	0.0036*		
	P	0.0521	0.1254		
	NXP	0.9948	0.4409		
Alfalfa Yield	**N**	0.0009*	0.6756		0.0222*
	P	0.0052*	0.1048		0.0084*
	NXP	0.7159	0.7675		0.7717

1. Effect of nitrogen

A. Yield

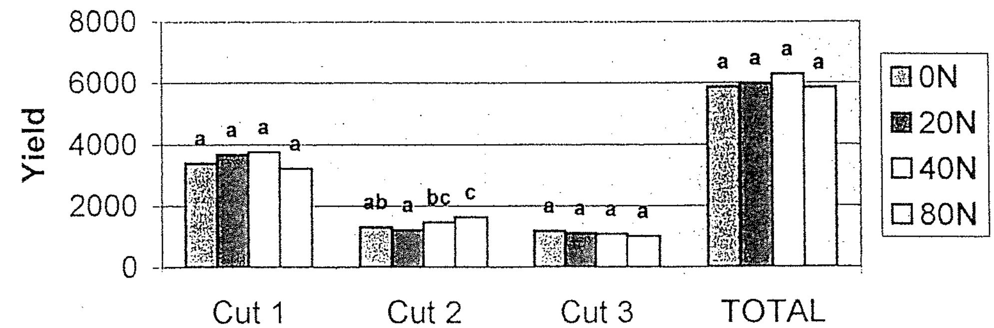
The effect of nitrogen on yield of forage harvested by simulated grazing at Calmar is shown in Figure 9. There was no significant effect of nitrogen on yield in either the first, second or third cuts.

Figure 7. Effect of Nitrogen on Yield of Mixed Forage Harvested as Simulated Grazing (Calmar B, 1997)



At Lac La Biche, nitrogen had a significant effect on yield of the second cut (P=0.0052). The yield increased from 1209 kg ha^{-1} at 20 N to 1633 kg ha^{-1} at 80 N. This response did not carry through to a significant response in total yield. As noted in previous years and in the results from Component A, mixed forage swards dominated by alfalfa may respond to fertilization with nitrogen when low soil temperatures in spring and early summer limits the nitrogen fixation process. Research at the Agriculture and Agri-Food Canada research station at Beaverlodge has shown nitrogen fixation is temperature sensitive and a soil temperature of 10 °C is necessary for nitrogen fixation to proceed. 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.

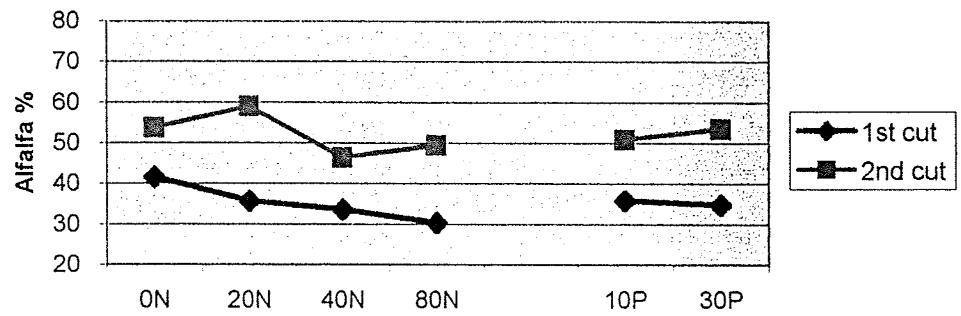
Figure 8. Effect of Nitrogen on Yield of Mixed Forage Harvested as Simulated Grazing (Lac La Biche, 1997)



B. Composition

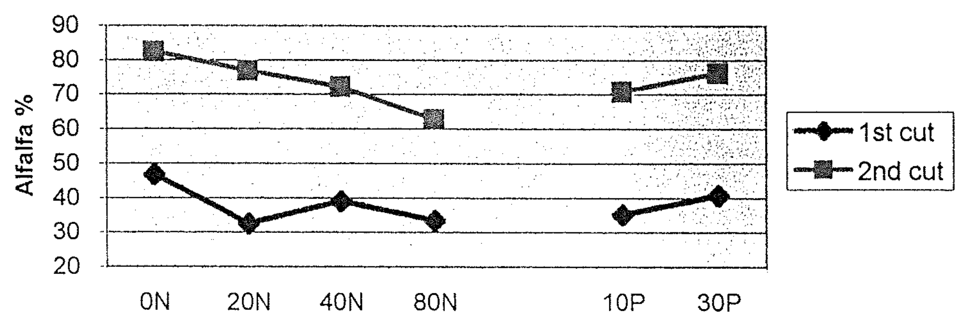
Nitrogen significantly reduced the percent alfalfa in the first cut at both locations (P =0.0417 at Calmar and P=0.0040 at Lac La Biche) and at Lac La Biche in the second cut (P=0.0036). The effect of nitrogen on percent alfalfa is shown in Figure 11 at Calmar and in Figure 12 at Lac La Biche. At Calmar, nitrogen decreased alfalfa from 42% at 0 N to 30% at 80 N in the first cut.

Figure 9. Effect of Nitrogen and Phosphorus on Percent Alfalfa in a Mixed Forage Sward (Calmar B, 1997)



At Lac La Biche percent alfalfa in the first cut decreased from 47% at 0 N to 33% at 80 N and from 82% at 0 N to 62% at 80 N in the second cut.

Figure 10. Effect of Nitrogen and Phosphorus on Percent Alfalfa in a Mixed Forage Sward (Lac La Biche B, 1997)

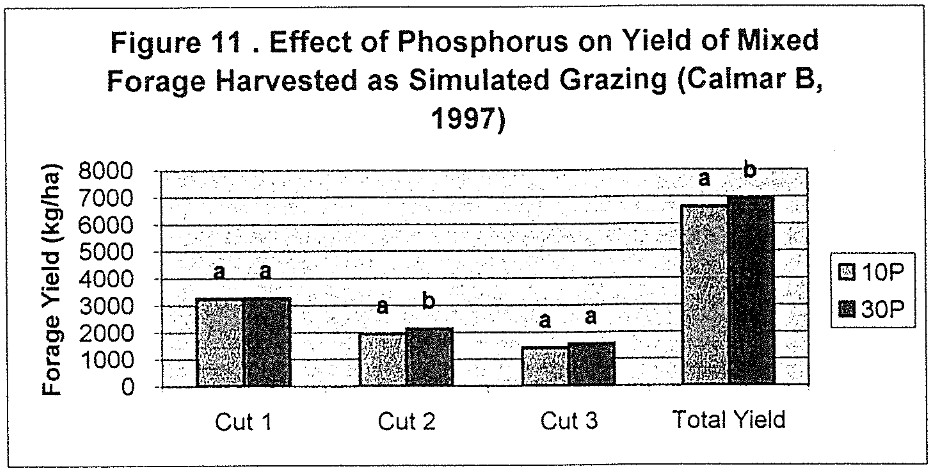


As noted in previous years, there was a substantial amount of white clover in the sward at Calmar and it has become a major species in the sward at Lac La Biche as well. At Calmar, the percent white clover in the first and second growth periods was determined. In the first growth period, percent clover was 19%, 24%, 14% and 12% at the 0, 20, 40 and 80 N rates respectively (data not shown). In the second cut, percent clover was 29%, 24%, 20% and 19% 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 where a two-cut management system is used.

2. Effect of phosphorus

A. Yield

Phosphorus significantly increased yield in the second cut at Calmar (P=0.0383) and total yield (P=0.0374). Yield of the second cut increased from 1954 kg ha^{-1}at 10 P_2O_5 kg ha^{-1} to 2125 kg ha^{-1} at 30 P_2O_5. Total yield increased from 6612 kg ha^{-1}at 10 P_2O_5 to 6945 kg ha^{-1} at 30 P_2O_5 (Figure 13).



It was 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.

Yield of alfalfa was determined by multiplying yield by percent alfalfa (data not shown). At Calmar neither nitrogen nor phosphorus had an effect on yield of alfalfa. At Lac La Biche, total yield of alfalfa from the first and second cuts decreased from 2662 kg ha^{-1} at 0 N to 2073 kg ha^{-1} at 80 N. Phosphorus increased yield of alfalfa in the first cut at Lac La Biche (P=0.0052) from 1181 kg ha^{-1} at 10 P_2O_5 to 1443 kg ha^{-1}at 30 P_2O_5 and total yield of alfalfa (P=0.0084) from 2129 kg ha^{-1} at 10 P_2O_5 to 2556 kg ha^{-1} at 30 P_2O_5.

B. Composition

At Calmar there was no effect of phosphorus on percent alfalfa. At Lac La Biche there was a trend for phosphorus to increase percent alfalfa in the first cut from 72% at 10 P_2O_5 to 77% at 30 P_2O_5 however this effect was not significant (Figure 12).

Acknowledgements

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