SUMMARY OF WCFL GRASS FORAGE RESEARCH IN SASKATCHEWAN AND WESTERN MANITOBA[1]

J.T. Harapiak[2]

In keeping with its commitment to encourage applied research designed to result in more efficient and economic use of fertilizers, Western Co-operative Fertilizers Limited has been conducting research on the response of forage stands to fertilizer throughout the prairie region. This research was funded by WCFL and the Pool/Co-op Agronomy Fund.

The subject of this paper is a series of completely randomized, six replicate trials initiated in 1975 and 1976 that were established on pure grass (predominantly brome) stands located in Saskatchewan and western Manitoba. The locations of the trials are identified in Tables I and II. For ease of data interpretation, the data was divided into two climatically different regions (i.e. Central Saskatchewan Region and the Manitoba-Saskatchewan Border Region). A total of 28 site years of data were collected in each of the two geographic regions. Unfortunately not all of the sites that were established in 1975 or 1976 are still being maintained. Changes in cropping plans on the part of the co-operating farmers and the consequent breaking up of the grass forage stands were the reasons that most of the sites were lost. The plots were randomly established wherever grass stands could be located while travelling through the region.

Table I: Locations and Years in which Grass Forage Trials were Maintained in Central Saskatchewan and along the Manitoba-Saskatchewan Border (WCFL, 1975/76/77/78)

Central Region

Location	Years
Langham	1975/76/77
N. Battleford	1975/76
Cut Knife	1975/76/77/78
Marsden	1975/76
Spaulding	1975/76/77/78
Outlook	1975/76/77/78
Kerrobert	1976/77/78
Bruno	1976/77/78
Watrous	1976/77
Pleasantdale	1976

1. Paper presented at the "Soils and Crops Workshop" held at the University of Saskatchewan, Saskatoon. February 19-20/79.

2. Chief Agronomist, WCFL, P.O. Box 2500, Calgary, Alberta T2P 2N1

Table I (continued)

Border Region

Location	Years
Yorkton	1975
Kamsack	1975
Swan River	1975/76/77/78
Dauphin	1975/76/77/78
Shoal Lake	1975
Russell	1975/76/77
Whitewood	1975
Wappella	1976/77/78
Rocanville	1976/77/78
Ethelbert	1976/77/78
Virden	1976/77/78
Theodore	1976

The main objective of this study was to evaluate the soil test as a means of predicting the response of crops to the most important fertilizer nutrients (i.e. N, P_2O_5, K_2O and S). The most convenient method of obtaining this assessment was to locate plots on permanent, pure grass forage stands, although it was recognized that forages and particularly pure grass forages are not a major factor in the agricultural economy in many of the regions in which the trials were located. Other factors that were evaluated at some locations was the response to magnesium, micro-nutrients, the relative performance of spring and fall applied nitrogen as well as the relative performance of urea and ammonium nitrate as nitrogen sources. Most of the treatments were spring applied. Soil samples were collected in the spring of the year and submitted to the respective provincial soil test laboratory for analysis.

The materials used as sources of nutrients were as follows:

Nitrogen - Ammonium nitrate except where urea is indicated

Phosphorus - Triple super phosphate

Potassium - Potassium chloride (0-0-62) at 25 lbs. K_2O/acre

Sulphur - Gypsum at 100 lbs./acre

Magnesium - Magnesium sulphate at 50 lbs/acre

Micro-nutrients - Davies Chelated Micronutrients at 50 lbs/acre (contains 2.10% MnO, 4.79% Fe_2O_3, 2.95% ZnO, 2.13% CuO, 2.8% B_2O_3, 0.034% MoO_3 and 8.5% S)

Nitrogen Plus Phosphate Response

The comparative forage response to nitrogen plus phosphate (2:1 ratio) in the two regions is tabulated in Table II.

Table II: Response of Grass Forages to Nitrogen Plus Phosphate (WCFL, 1975/76/77/78)

Region	Check Yield (Cwt/Acre)	Incremental Yield Increase (Cwt/Acre) 50-25-0	75-37-0	100-50-0	150-75-0
Central	14.9	15.4	6.9	3.4	3.7
Border	21.6	15.2	5.8	3.8	0.9

The average yield was about 6.0 cwt less for the plots located in the central regions compared to the plots located in the border region although the average difference narrowed to about 3.0 cwt/acre at the highest rate of nitrogen applied (i.e. 150 lbs N/acre) indicating a greater need for fertilizer nitrogen for the plots located in the central region.

If as often suggested, it takes 60 lbs/acre of nitrogen to produce 1 ton of hay/acre and possible differences in climatic limitations are ignored, based on an average check yield of 14.9 cwt/acre in the central region, these soils mineralized an average of 45 lbs/acre of nitrogen. In the border region, the average check yield was 21.6 cwt/acre, suggesting that these higher organic matter soils mineralized an average of 65 lbs/acre of nitrogen. Based on the soil test values of spring collected soil samples the average nitrate-nitrogen content (0-24") of the plots located in the central and border regions were 28 and 20 lbs/acre respectively. Less fall regrowth due to more severely limiting moisture supply is the likely explanation for the higher levels in the central regions.

The relative response to nitrogen and to nitrogen plus phosphate is tabulated in Table III where it can be calculated that at the rate of 100 lbs. N/acre, for the central and border regions 89% and 78% respectively of the nitrogen plus phosphate response was accounted for by nitrogen alone. From this data it is apparent that the bulk of the response was to nitrogen

Table III: Average Response of Grass Forages to Nitrogen and Phosphate in Central Saskatchewan and along the Manitoba-Saskatchewan Border (WCFL, 1975/76/77/78)

	Yield Increase (Cwt/Acre) Rate of Nutrients Applied (Lbs/Acre)		
Region	100-0-0	100-50-0	Avg. NO_3-N (0-24") (Lbs/Acre)
Central	22.8	25.7	28
Border	19.3	24.8	20

alone and response to nitrogen in the central region was larger despite the higher soil test levels of available nitrogen as indicated by a soil test taken early in the spring of the year.

Phosphate Response

The average response to phosphate in addition to nitrogen is tabulated in Table IV where it is evident that at the rate of 100 lbs N/ acre, more of the response to phosphate was accounted for in the first 25 lbs/acre of P_2O_5 applied. If hay is valued at \$2.50/cwt (i.e. \$50.00/ton) and P_2O_5 at 20¢/lb. (i.e. \$5.00 and \$10.00/acre respectively for two rates of P_2O_5 applied), on average, it was not economical to apply the extra 25 lbs. of P_2O_5.

Table IV: Average Phosphate Response of Grass Forages in Central and Border Regions (WCFL, 1975/76/77/78)

Region	Control Yield (Cwt/Acre) 100-0-0	Yield Increase (Cwt/Acre) Rate of P_2O_5 (Lbs/Acre) 25	50	Avg. P (0-6") (Lbs/Acre)
Central	37.7	1.9	2.9	18
Border	40.9	4.3	5.5	17

In fact, for the central region trials, the first 25 lbs/acre increment of P_2O_5 was just barely economical despite the fact that the average available soil P (0-6") levels for the two regions were almost identical.

The yield data was also broken down according to available P (0-6") levels as a means of measuring how well the soil test was predicting the need for fertilizer phosphate. This data is summarized in Table V. It is interesting to note that there was a consistent and perhaps coincidental

Table V: Response of Grass Forages to Phosphate According to Available Soil Test Phosphate Levels (WCFL, 1975/76/77/78)

Available P (0-6") Lbs/Acre Range	Average	Site-Years of Data	Control Yield (Cwt/Acre) 100-0-0	Yield Incr. (Cwt/Ac.) Rate of P_2O_5 (Lbs/Ac.) 25	50
≧10	7	12	35.2	7.0	9.8
11-15	13	20	34.9	3.0	3.5
16-25	22*	14	42.5	1.7	4.3
>25	34	10	48.5	0.4	(1.3)

* Note: All but one of these sites were in the range of 21-25 lbs. of available P (0-6") per acre.

trend towards higher yields in the 100-0-0 treatments as the levels of soil available P increased. Based on the data presented in Table V, it would appear that the soil test is performing quite satisfactorily in predicting the phosphate requirements of grass forages adequately supplied with nitrogen It would also appear that 50 lbs. of P_2O_5/acre could be economically applied on soils with available P levels of 10 or less lbs/acre. If no consideration is given to the possibility of improved forage quality, it appears that additions of fertilizer phosphate to grass forages grown on soils in the 21-25 lbs/acre of available P category would not be economical. More data needs to be collected on soils in the 16-20 lbs/acre category.

At some sites, the potential benefit of applying a very low rate of P_2O_5 (i.e. 10 lbs/acre) was evaluated and this data is summarized on Table VI and VII. It is apparent that on soils with very low levels of

Table VI: Benefit of Applying Three Rates of Fertilizer Phosphate to Grass Forages on Soils Very Low in Available Phosphate (WCFL, 1975/76/77/78)

Rate of P_2O_5 (Lbs/Acre)	Yield Increase* (Cwt/Acre)
10	3.4
25	6.4
50	10.8

* Plots located on soils with $\geq$ 10 lbs/acre of available P in the 0-6" level.

available P, the lowest rate (i.e. 10 lbs/acre of P_2O_5) was very economical. However, as illustrated in Table VII, at higher soil test levels of available P, the application of 10 lbs/acre of fertilizer P_2O_5 appeared to decrease yield.

Table VII: Influence of Low Rates of Phosphate on Yield of Grass Forage Grown on Soils of Varying Available P Levels (WCFL, 1975/76/77/78)

Available P Category	Yield Increase (Cwt/Acre)
$\geq$10	3.4
11-15	(2.3)
16-25	(0.5)
$>$25	(0.4)

This type of yield depression on grass forages has been previously observed with low rates of nitrogen but this is the first time that a depression in yield has been reported resulting from the application of a low rate of phosphate to grass forages adequately supplied with nitrogen.

Potash Response

The average response to potash on grass forages adequately supplied with nitrogen and phosphate is tabulated in Table VIII and indicates that on average, there was very little response to potash applied at the rate of 25 lbs K/acre. There was slightly more response to potash

Table VIII: Average Potash Response of Grass Forages in the Central and Border Regions (WCFL, 1975/76/77/78)

Region	Yield (Cwt/Acre) 100-50-0	Yield (Cwt/Acre) 100-50-25	Avg. K (0-6") (Lbs/Acre)
Central	40.6	41.6	540
Border	46.4	47.8	346

at the higher yielding plots located in the border region which also had slightly lower average level of available potassium.

The potash response data was also evaluated according to available potassium levels in the 0-6" soil layer. This data is summarized in Table IX and indicates quite clearly that the soil test was performing quite inconsistently in predicting the response of grass forages to

Table IX: Response of Grass Forages to Potash According to Available Soil Test Potassium Levels (WCFL, 1975/76/77/78)

Available K (0-6") Lbs/Acre		Site-Years	Cwt/Acre	
Range	Average	of Data	Control Yield 100-50-0	Yield Increase*
$\leq$ 250	201	13	40.0	2.6
251-500	354	15	45.7	(0.2)
201-1000	645	28	44.0	1.6

* Response to 25 lbs. K/acre.

fertilizer potash. These findings are not that surprising since research in Montana indicates that physical factors such as soil temperature, moisture content, compaction, texture and slope are all more important in predicting or explaining the response to added potash than is the soil test levels of available potassium.

In these trials, the only physical factor that could be evaluated was soil texture and this data is summarized in Table X. Soils were broken down according to surface texture, although increasing clay

Table X: Response of Grass Forages to Potash According to Soil Texture (WCFL, 1975/76/77/78)

Soil Textural Range	Avg. K (0-6") (Lbs/Acre)	Site-Years of Data	Cwt/Acre 100-50-0	Cwt/Acre 100-50-25	Cwt/Acre Yield Incr.
LS-VFSL	394	20	38.6	42.8	4.2
L-L/CL	528	25	44.8	45.3	0.5
L/C-C	308	11	53.1	50.5	(2.6)

content below the surface layer was also taken into consideration. It is evident that increasing clay content was associated with an increase in the yield of the control (100-50-0) treatment. It is also apparent the classification on the basis of textural category was much more effective in predicting response to potash than was the soil test for available potash.

It is interesting that based on textural categories, contrary to normal expectations, the heavier textured soils had the lowest average levels of available K in the 0-6" soil layer. Farmers have noted that available potassium levels appear to decline in some field when taken out of annual crop production and switched to forage production. The fact that levels seem to rebound when the forage fields are broken up suggests that some form of physical manipulation may be required to release available potassium on the heavier textured soils.

The fact that based on textural categories, the soils that tested lowest in available potassium responded negatively to added potash combined with the fact that a simple textural test was more successful in explaining the response to added potash than was the standard soil test suggests that perhaps there exists a need to reassess the soil test procedures used for predicting potash requirements. It would also probably be beneficial to involve pedologists with their soil classification skills in any new research into improving the predications of response to added potash.

Sulphur Response

The average regional response to sulphur is tabulated in Table XI and indicates quite surprisingly that on average there was more of a response to sulphur in the lower rainfall central regions than in the higher rainfall regions along the Manitoba border. No average levels

Table XI: Response of Grass Forages on the Central and Border Regions (WCFL, 1975/76/77/78)

Region	Cwt/Acre NPK	Cwt/Acre NPKS	Cwt/Acre Yield Increase
Central	41.6	43.9	2.3
Border	47.8	48.3	0.6

of soil available sulphur are included for the sulphur data because the ranges encountered were so wide that an average value would be meaningless.

The test sites were also categorized according to sulphur response pattern and the data is summarized in Table XII. It was surprising to note that in 43% of the cases, the average response to 18 lbs/acre of sulphur exceeded one quarter of a ton per acre of grass forage.

Table XII: Categorization of Yield Data According to Sulphur Response Pattern (WCFL, 1975/76/77/78)

Category	Site-Years of Data	Cwt/Acre NPK	NPKS	Yield Increase
Responsive	24	39.6	45.0	5.6
Non-Responsive	25	47.9	47.5	(0.4)
Negative Response	7	50.8	44.9	(5.9)

It should be noted that data from individual sites was placed in only one category despite the fact that the sulphur response may have not been consistent from year to year. In fact over a period of years, we observed a great deal of variability in response to sulphur at some sites. It is possible that the response may be climatically influenced as a result of soluble sulphur products fluctuating up and down within the profile depending on precipitation patterns.

Micronutrient and Magnesium Response

The response to additions of micronutrients and magnesium were evaluated in 21 site-years of data collected. This data is summarized in Table XIII and suggests there was no significant benefit from application of either of these materials. However, at one site (located near Watrous),

Table XIII: Average Response of Grass Forages to Micronutrients and Magnesium (WCFL, 1975/76/77/78)

Region	Site-Years of Data	Average Yield (Cwt/Acre) NPKS	NPKS+M	NPKS+Mg
Central	9	44.0	42.9	44.9
Border	12	51.5	52.2	50.4

there was a response of 8.2 and 2.2 cwt/acre respectively in 1976 and 1977 to the addition of magnesium. Similar occasional responses to magnesium have been observed in trials located in Alberta.

Urea vs Ammonium Nitrate

At each of the sites, urea was compared to ammonium nitrate as sources of nitrogen for spring applications at 50 and 100 lbs N/acre at each of the 56 site-years of data collected. The data is summarized in Table XIV and indicates that in the Central and Border regions, urea

Table XIV: Average Response of Grass Forage to Spring Applied Urea and Ammonium Nitrate (WCFL, 1975/76/77/78)

Region	Check Yield (Cwt/Acre)	Yield Increase (Cwt/Acre)*	
		Nitrate	Urea
Central	14.9	20.6	17.2
Border	21.6	20.0	15.5

* Nitrogen applied at 50 and 100 lbs N/acre.

was 82% and 78% respectively as effective as nitrate. At the CDA Research Station in Brandon, urea has consistently outperformed nitrate as a source of nitrogen for grass forages. However, in the WCFL trials only one harvest was taken per year while at Brandon, two cuts were taken each year. There is a distinct possibility that the relative performance of urea improves under a two cut system.

Fall vs Spring Nitrogen

At 12 site-years, urea and nitrate were compared fall and spring at the rate of 50 lbs N/acre. This data is summarized in Table XV and indicates that on average, fall applied nitrogen was 97% as effective as spring applied nitrogen for grass forages.

Table XV: Average Response of Grass Forage to Fall and Spring Applied Nitrogen (WCFL, 1976/77/78)

Region	Site-Years of Data	Check Yield (Cwt/Acre)	Yield Increase (Cwt/Acre)*	
			Fall	Spring
Central	3	15.8	14.2	16.4
Border	9	23.4	16.8	16.5

* Nitrogen as urea and nitrate applied at 50 lbs N/acre.

Summary

Based on information collected over a large number of grass forage fertilizer trials, the following conclusions can be made:

1) The plots located in the Border region had a slightly higher yield potential due to the more favorable precipitation of this region.

2) Check yields were higher in the Border region probably due to the higher amount of nitrogen released from the higher organic matter content of these soils.

3) Plots located in the Central region responded more to higher rates of nitrogen despite their slightly higher NO_3-N content in the spring of the year.

4) There was generally a stronger response to phosphate in the Border than in the Central region despite similar levels of available phosphate. On average, 25 lbs/acre of P_2O_5 was quite economical in the Border region but was barely economical in the Central region.

5) The standard test used for available phosphate performed quite well in predicting the response of grass forages to fertilizer phosphate.

6) Low rates of phosphate fertilizer (i.e. 10 lbs of P_2O_5/acre) tended to depress the yield of grass forage except on those soils with the lowest levels of available phosphate.

7) The current test used for determining available potassium did not predict the need for fertilizer potash as accurately as a separation based on soil texture.

8) On heavier soils, available potassium levels under grass forage stands may be depressed to the extent that a need for potash fertilizer may be indicated. The application of potash on these soils may result in a negative yield response.

9) Responses to sulphur were encountered more frequently in the Central than in the Border region.

10) At almost one-half of the sites, the average response to sulphur exceeded 5.0 cwt/acre.

11) No benefit was demonstrated as a result of applying micronutrients.

12) No consistent benefit demonstrated from the application of magnesium except for one relatively large unpredictable response at Watrous.

13) Based on a single cut system, the relative efficiency of urea as a nitrogen fertilizer compared to ammonium nitrate was 80%.

14) Fall applications of nitrogen were 97% as effective as spring applications.