Fertility Management in Forages

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Introduction

Perennial forage crops could be viewed as the ideal crop in terms of protecting soils from erosion. However, this benefit is realized only if the forage stand is kept in a profitable and productive state for several years. While there are several management practices that influence productivity and longevity, fertility management would rank very high on the list.

As shown in Figure 1, tame hay production has grown steadily in Saskatchewan over the past 5 decades to the point where over 3 million acres of production currently exist. Over this same time frame, yields have ranged from 0.6 to 1.9 tons per acre. The chart also reveals that a slight downward trend in tame hay yields is occurring. This could be a reflection that a greater number of marginal acres are being sown to tame hay without the adoption of appropriate management techniques to optimize production.

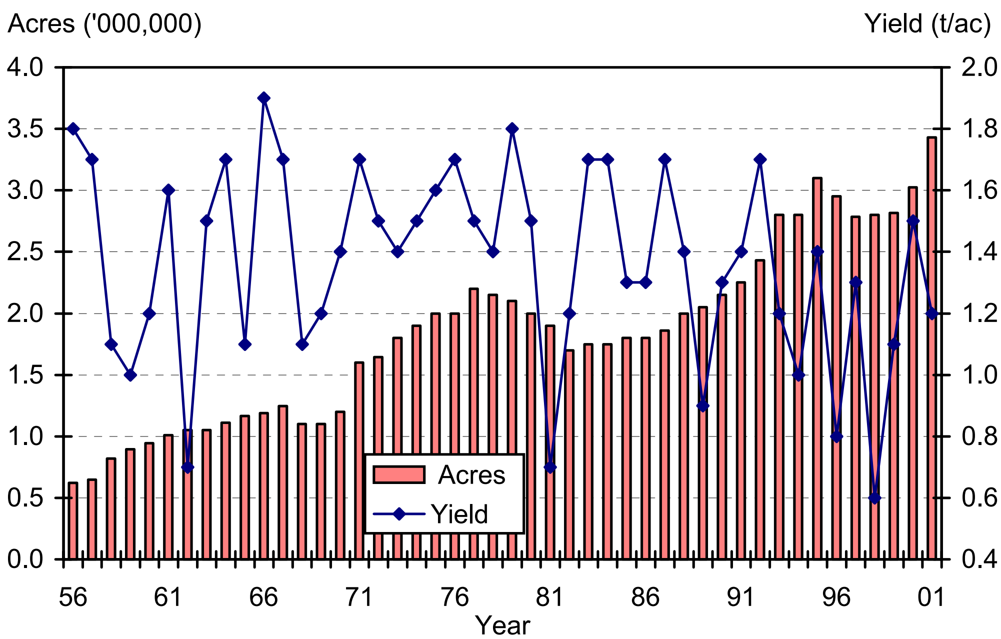

Figure. 1. Yield and Acreage Trends of Tame Hay Production in Saskatchewan

While it is difficult to obtain accurate information relating to fertilizer practices on established forages, many agronomists agree that forages are severely under-fertilized. This is not because forages do not have a high nutrient requirement. In fact, as shown in Figure 2, established perennial forages have an annual nutrient demand in excess of conventional annual crops such as wheat. Another factor contributing to nutrient deficient forages is the fact that they are often established on marginal land where the nutrient supplying power of the soil is quite limited.

This combination of producing a crop with a high nutrient demand on soils that are characteristically low in fertility clearly points to the need for developing a fertilizer program for forages.

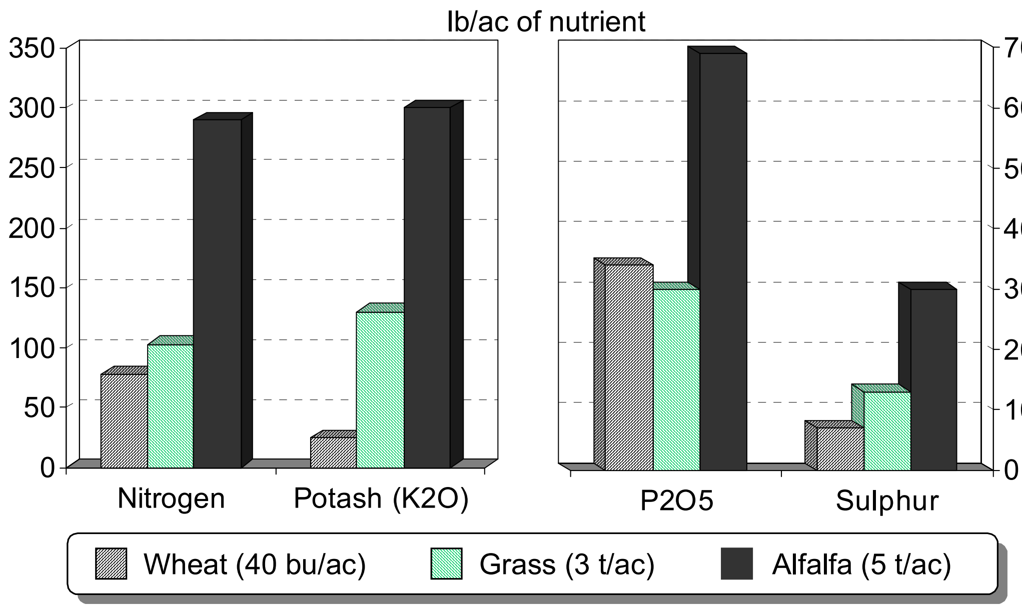

Figure. 2. Nutrient requirements of forage crops compared wheat grain. (Source: Nutrient Removal Charts, 1992)

Fertilizer Guidelines Based on Legume Content of Forage Crop

Information in this paper deals with fertility requirements of perennial forages intended for hay (livestock feed) production only. Different recommendations would apply for forages intended for seed production.

Fertilizer recommendations for forages begin by defining the stand. Is the crop predominantly grasses or legume or a mixture of the two? General forage fertilizer guidelines, as developed by Dr. L. Bailey, are shown in Figure 3. Based on these guidelines, the recommended N rate is adjusted according to the proportion of legume contained in a mixed stand. Since legumes are capable of fixing their own N requirements, the need for fertilizer N decreases as legume content increases.

Start by estimating the amount of N required as though you were dealing with a pure grass stand. Assume 80 lb/ac. Subtract from this the percent legume multiplied by that N rate. For a stand that contains 60% legume, 48 pounds of N (i.e. 60% of 80 = 48) would be subtracted from the initial 80 pound N rate. The remaining 32 pounds would be the recommended N for a mixed stand containing 60% legume.

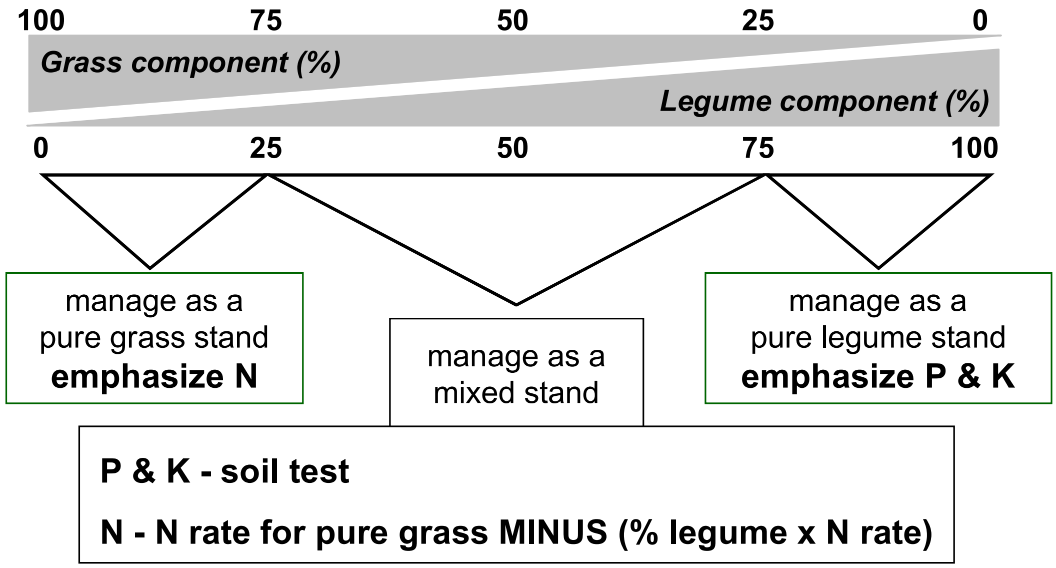

Figure 3. Guideline for N application rates on mixed forage stands. (L. Bailey, CDA, Brandon)

Grass Forages

There is great diversity in the number of perennial grass species available to prairie farmers each with their own strengths and weaknesses. Regardless of whether tame grasses are grown for pasture, hay or in response to an extreme environmental condition (i.e., salinity), their N requirements are usually very high. Fertilizing grasses with nitrogen can produce some very striking responses.

Yield response of grasses to additions of phosphorus, potassium and sulphur tend to be more inconsistent and variable. The need for these elements is best determined by soil testing. Some "on farm" testing (demonstration strips) is also encouraged in order to help determine fertilizer requirements.

Grasses Hunger for Nitrogen

Low levels of soil N are common in pure grass stands. This has largely been attributed to the fact that the stands remain undisturbed (untilled) and thus very little N is released by mineralization (i.e., conversion of organic matter into plant available N). The crop quickly consumes any N that is released during the growing season.

Grass forage research conducted by Dr. Mahli at several locations produced N response patterns that are frequently seen in grass forages (Figure 4). In most cases yields doubled due to the added N fertilizer. Since these sites were located in the Black soil zone, moisture conditions could be considered good to excellent. Depending on values placed on N fertilizer and forage hay the optimal N rate falls into the range of 100 – 175 pounds per acre.

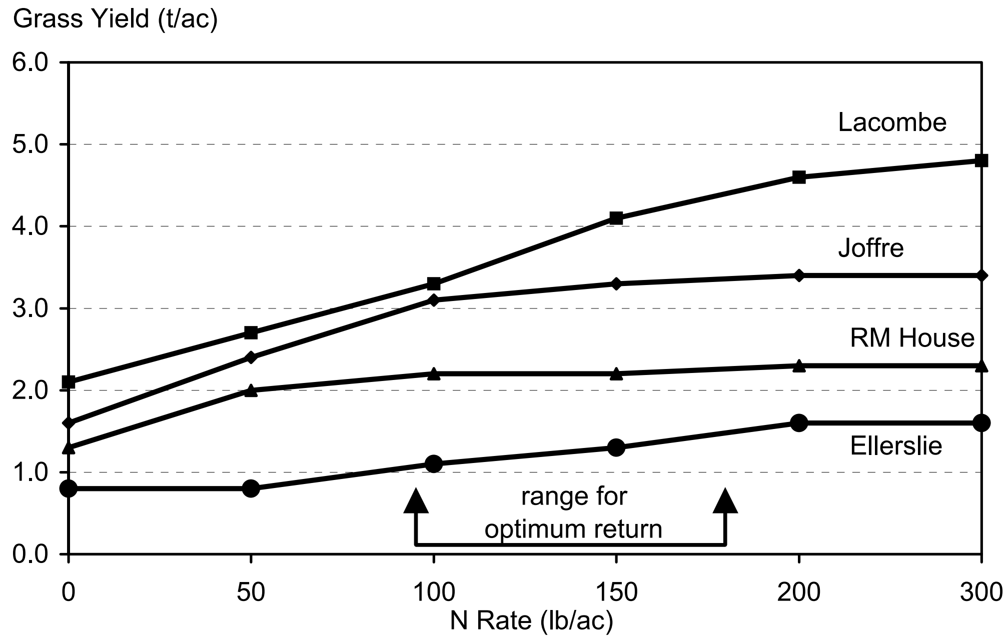

Figure 4. Response of bromegrass to N fertilizer by location (Mahli, 1986)

Generally speaking the optimum N rate for grass stands in the Black and Gray soil zones falls in the 80 – 150 pound range. In the drier regions, rates of 50 - 70 pounds of N per acre could be feasible. Improved hay quality (protein and digestibility) is also a measurable benefit of N fertilization.

Nitrogen Sources and Times of Application

Several nitrogen products are available for surface application onto forage stands. Extensive research has been conducted comparing urea (46-0-0) to ammonium nitrate (34-0-0). There are greater supplies of urea available and it also has a slight price advantage in terms of dollars per unit of N. These advantages, however, have to be weighed against its potentially poor performance when broadcast applied.

For over 15 years, Westco maintained 4 bromegrass trials in south-central Alberta where broadcast applications of urea and ammonium nitrate were compared at 4 different dates of application. Dates were early fall, late fall, early spring and late spring. This would roughly correspond to early October, early November, mid April and late May or early June respectively. Results of 58 site-years of data from these trials are shown in Figure 5. N was applied at 100 pounds per acre in all treatments.

It is interesting to note that grass yields were roughly doubled with the 100 pound application of N. Overall top yields were achieved with an early spring application of ammonium nitrate. At all application dates 34-0-0 consistently outperformed 46-0-0. Averaged over the 4 application dates, urea was only 80% as effective in increasing yields compared to ammonium nitrate.

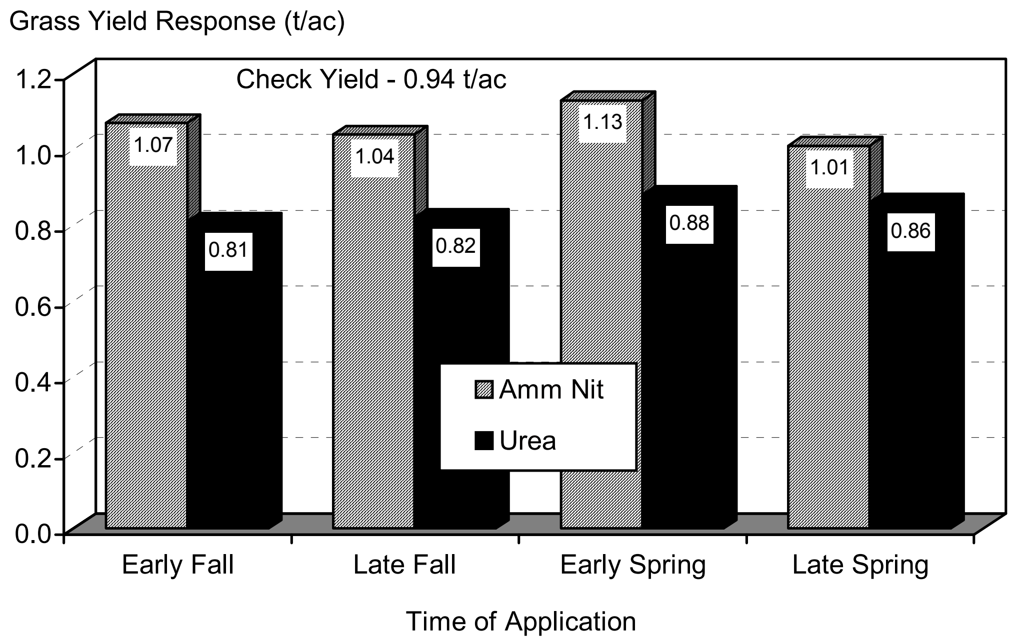

Figure. 5. Yield response of bromegrass to 100 lb N/ac as urea and ammonium nitrate at 4 times of application (Westco, 1974-1988).

The relatively poor performance of urea in broadcast applications is due to volatilization (gassing off) losses. When broadcast urea is left exposed to the atmosphere it break down and releases ammonia gas. The longer the urea remains on the surface and in contact with residues the greater the potential loss of N as gaseous ammonia. Once there has been significant rainfall to transport the urea into the soil, this loss mechanism is halted.

Urease Inhibitors

Chemical compounds, known as "urease inhibitors", are currently being introduced into Western Canada. These liquid compounds can be impregnated with urea or mixed with liquid UAN (28-0-0, a urea containing fertilizer). They reduce volatilization losses by inhibiting the urease enzyme, which is responsible for triggering the urea hydrolysis reaction that results in gaseous ammonia losses. "Agrotain" is a urease inhibitor that is commercially available in Canada.

While there is limited research work dealing with urease inhibitors in western Canada, U.S. research has shown that "Agrotain" inhibits volatilization for up to 14 days. This allows time for a significant rainfall event to dissolve and transfer the urea in to the soil. A desired protection period (up to a maximum of 14 days) can be achieved by varying the amount of "Agrotain" that is applied to the urea or mixed with UAN. At recommended rates, the cost of urea coated with "Agrotain" is very similar to ammonium nitrate on a cost per unit of N basis. Other considerations for using Agrotain treated urea as opposed to ammonium nitrate include:

facilities for impregnation (farmer, retail or wholesale warehouses)

improved blending capability (there are a limited number of retail facilities that offer ammonium nitrate blending due to concerns relating to urea contamination) urease inhibitor rates can be tailored to the current situation or environmental conditions

public perception and safety issues relating to ammonium nitrate

Other Nitrogen Fertilizers

Ammonium sulphate is often considered as a nitrogen source in forage production because ample volumes of "fines" grade ammonium sulphate often become available. Westco forage research in the foothills of Alberta has shown that this product is equally effective to ammonium nitrate. There is also the potential added benefit of the sulphur that is supplied by the product.

Liquid UAN (28-0-0) is another option for fertilizing forages. Approximately one half of the N contained in UAN exists as urea and therefore volatilization losses can occur. Application method (surface band vs spray) will influence the amount of N loss. If the product is surface banded (i.e., dribbled) expected performance is about 85 – 95% of broadcast ammonium nitrate. Spray applications are much more vulnerable to loss (due to increased contact with surface residues) and performance could drop to about 75 – 80% compared to broadcast ammonium nitrate.

Legume Forages

Legume crops (i.e., alfalfa, clovers, etc.) have the reputation of being "soil builders". They have earned this reputation because of their ability to fix atmospheric nitrogen and produce an abundance of high quality plant material.

These high yielding forage crops also have the ability to remove from the soil large quantities of other essential nutrients such as P, K and S as well as micronutrients. This must be kept in mind when creating a fertilizer program for the legume crop as well as for succeeding crops.

Adding N to a legume stand is not normally required if the plants are properly inoculated with the correct strain of bacteria. The bacteria can fix as much as 100-300 pounds of N in a single season. In exchange for the N, the legume plants supplies the bacteria with carbohydrates. Since this is a mutually beneficial relationship, a healthy legume plant is vital in order to keep the bacteria functioning to their potential. In other words, if a legume crop is stressed with a nutrient deficiency, the N fixing bacteria will not be as effective in supplying the crop with N.

Phosphate for Legumes

Most legume forage crops will benefit from a phosphate application. It may not occur as quickly as an N application in grasses but over the long-term, legume forages will produce economical returns to phosphate applications. The magnitude of response will vary depending on yield potential and soil P status (Figure 6).

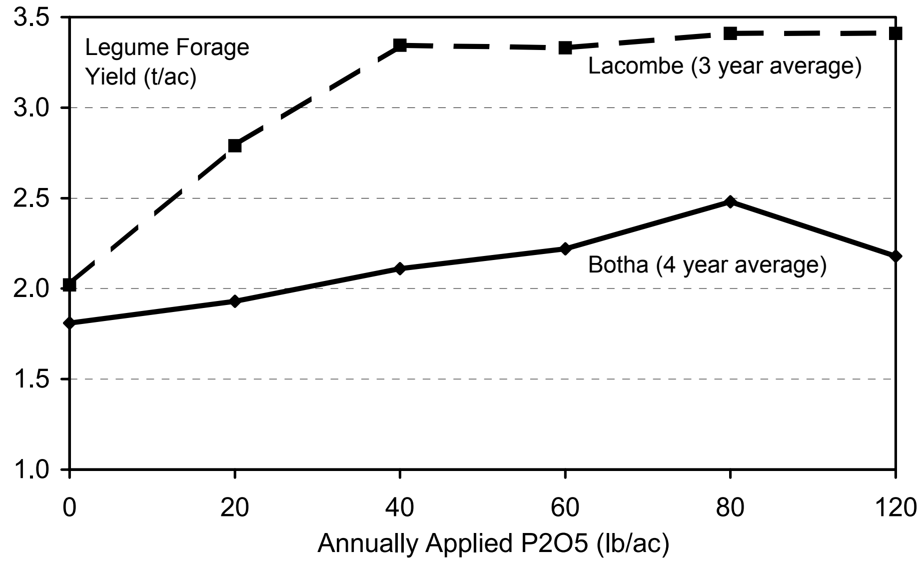

Figure 6. Yield response of alfalfa at two central Alberta locations due to increasing rates of broadcast applied phosphate. (Source: Mahli, Lacombe, CDA)

The larger P response that occurred at Lacombe was attributed to lower soil P levels and better moisture conditions. Soil P levels for Lacombe and Botha were 16 and 24 pounds per acre respectively.

Compared to grasses, legume crops appear to be more responsive to surface applied P. Repeated annual applications of P (i.e., 2-3 years) appear to be important before the full benefit of the applications can be realized. Incorporating a 2-3 year supply of P into the soil prior to stand establishment can reduce this lag time. Following that, annual applications of P still appear to be important to achieve optimum yields.

Grass-Legume Mixtures

A mixed stand refers to grass-legume mixtures where the legume component makes up 25% to 75% of the total stand. Stands containing less than 25% legume should be managed as pure grass stands where nitrogen is the key nutrient. If the legume component is greater than 75%, these stands should be treated as a legume stand.

Nitrogen fertilizer recommendations of mixed stands were discussed earlier and were based on legume content (Figure 3). Some N is required to satisfy the nutrient requirements of the grasses, however, too much N will over stimulate grass production at the expense of the legumes.

Importance of Phosphate in Mixed Stands

Phosphate is important in mixed stands and response characteristics are similar to that achieved in pure legume stands. Yield responses may not be immediate but the long-term benefits are worth waiting for.

In 1979 Westco established 16 mixed forage trials in south central Alberta. The objective of the long-term study was to evaluate the impact of various fertilizer treatments on mixed forage yield and sward composition. After 4 years of the study, 63 site-years of data were accumulated.

Average phosphate yield response in each of the 4 years of the study are shown in Figure 7. In the first year yield responses were quite small – only 17%. However, with each successive application phosphate responses became more apparent. The average yield response in the first and fourth year amounted 0.10 and 0.63 tons/acre respectively.

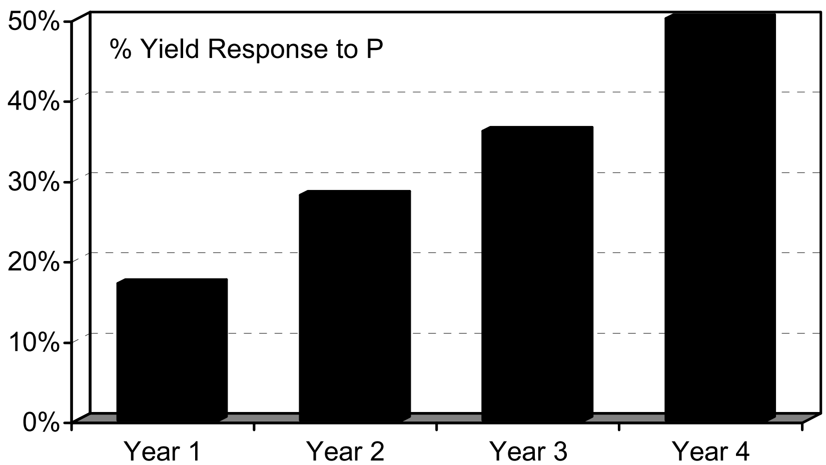

Figure 7. Influence of successive applications of phosphate fertilizer on yield of mixed forage stands in south central Alberta. (Westco, 1979-1982)

Two factors are felt to be responsible for this surging P response. Firstly, there may be some subtle downward migration of the fertilizer P over time. In addition, Dr. Bailey has also reported that alfalfa is capable of producing a very dense mat of fine root hairs near the soil surface. It is felt that this shallow, yet, aggressive rooting system is capable of utilizing surface applied phosphate. This building P response due to successive applications of P illustrates the importance of evaluating P applications over a number of years.

Phosphate is applied to mixed stands largely to satisfy the P requirements of the legume sward. Thus, P fertility can be used, to a degree, to modify legume composition. Annual applications of phosphorus (25 – 50 lb P_2O_5/ac) on a mixed stand will help maintain or strengthen the legume component.

Potash for Forage Crops

Since most prairie soils have adequate soil K levels, potassium does not get a lot of attention in many fertility programs. However, when dealing with perennial forage crops that are grown for the purpose of hay, potassium commands a bit more attention.

Forage crops are often established on marginal land (sandy and peat soil), which are often deficient in K. Further to this, forage crops remove considerably greater quantities of K compared to crops that are harvested for seed only. This stems from the fact that their K requirements are very high (see Figure 2) and large amounts of potassium are found in the foliage. Since forage crops are usually grown for their foliage, large amounts of potassium are removed with each harvest. A legume forage crop managed for two or more cuts can remove as much as 300 pounds of potassium from the soil each year.

Potassium removal by forage crops is directly related to yield. A management level that produces high yielding crops will result in more rapid soil mining compared to crops produced under less than ideal conditions. Figure 8 demonstrates the relationship between management level (in this case, N application rate) and its impact on soil K reserves.

After 16 continuous years of N applications at the indicated rates, all treatments were soil sampled to assess nutrient levels and soil chemical properties. The bars on the graph represent yield at each of the indicated N rates. The line on the graph represents soil K levels after 16 years of production. The increased production due to N resulted in a substantial decline in soil K levels. After 19 years of production soil K levels in the 100 pound treatment were only 61% of that found in the unfertilized treatment. This points to the need for monitoring soil potassium levels on land where intensive forage production is practiced.

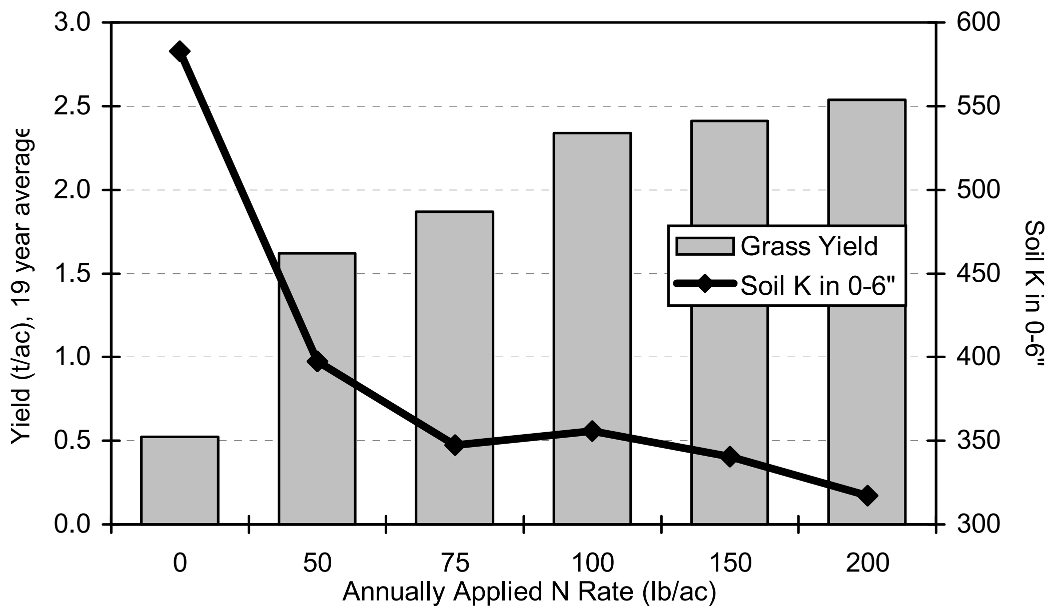

Figure 8. Impact of long term N applications on grass forage yield and soil K removal. (Westco)

Supplying Sulphur to Forage Crops

A large number of forage acres exist in the Grey Wooded soil zone, which is well known for its sulphur deficient soils. Both grasses and legumes respond very well to an application of sulphur, especially on soils exhibiting a low sulphur status. Since sulphur and nitrogen are both critical for protein synthesis, a sulphur deficiency will be more pronounced in a legume crop due to its higher protein content. A sulphur deficiency will also reduce N fixation in legume crops.

Sulphur vs Sulphate

Sulphur fertilizers fall into two general categories – sulphate sulphur (e.g, ammonium sulphate, 21-0-0-24) and elemental sulphur (e.g., 0-0-0-90 or 0-0-0-95). Plants use the sulphate form, which is very mobile in the soil. Sulphate products provide confidence of performance in the year of application. Since elemental S products must undergo biological oxidation before they are plant available there is always some degree of uncertainly as to when the sulphur will indeed be plant available.

Since forage crops typically receive broadcast applications of fertilizers, this crop lends itself fairly well to elemental sulphur products. Broadcasting without incorporation favours the physical breakdown and dispersion of the elemental sulphur prills. This, in turn, favours the conversion of sulphur to sulphate. This is not to say that one can rely on elemental S products in the year of application – it simply states that surface application will become available more quickly than a seedrow or band application. Research conducted by Alberta Agriculture shows that there is about a one-year lag time between application and plant availability of broadcast elemental sulphur in forage crops.

In a situation where a sulphur deficiency has been identified and requires immediate correction, the sulphate form is strongly recommended. A sulphate product, if applied early enough, will correct the problem in the year of application. Elemental sulphur products have a good fit in a fertilizer program where they are included every year, especially if broadcast applied.

Summary

Capturing the full benefits of established forage crops involves close attention to fertilizer management. The fact that forage yields can be doubled, if not tripled, with proper fertilizer management is a feature that forage producers cannot afford to overlook. There is also the added benefit of improved feed quality and extending stand longevity. Far too often established grass stands have been incorrectly diagnosed to as being “sod bound” and taken out of production. In many of these situations, an application of nitrogen could have restored production. This approach would be far more cost effective than breaking up the stand and re-establishing it.

As indicated earlier, poor land is often relegated to forage production. It may be hilly, stoney or have poor moisture holding properties. Establishing a forage crop on land with these characteristics can be challenging and it is not a task that one wants to embark upon too often. A sound fertility program is not only important for optimizing production but it will also mitigate the need for re-establishment.