Fertilizing Alfalfa Forage

Alfalfa is the most commonly grown forage legume in Manitoba with about 870,500 acres (352,200 hectares) in crop – Census 2021 data. According to Manitoba Agricultural Services Corporation statistics, the average yield of alfalfa forage in Manitoba is 2.3 tons/acre (5.7 tonnes/hectare). But, with proper fertilizer management, yields of 3.5 to 5.5 tons/acre (8.6 to 13.6 tonnes/hectare) of high protein forage alfalfa can be obtained on a wide range of Manitoba soils.

Alfalfa can be successfully grown on all soils except organic soils, poorly drained soils and droughty, coarse-textured soils. Alfalfa will tolerate a moderate amount of salinity during the germination stage, but once established it will tolerate higher amounts of salt (up to eight millisiemens/centimetre if properly fertilized). Because soil acidity interferes with nitrogen fixation, it is very difficult to establish alfalfa on highly acidic soils (pH of 6.5 or less). Fortunately, acidic soils are not common in Manitoba.

Fertilizing Strategy

A well-planned fertilizer program is necessary for alfalfa forage production. The fertilizer program for alfalfa should achieve three main goals:

1. Provide levels of nutrients that result in maximum yield and quality of forage.
2. Provide an environment in which Rhizobium bacteria can efficiently fix nitrogen. This eliminates the need for nitrogen fertilizer and also ensures forage of high protein content.
3. Provide soil fertility and other soil conditions that ensure longevity of the alfalfa stand.

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Step One – Soil Test

The first step in a fertilizer program for alfalfa, whether for establishing a new stand or for existing crops, is to conduct a proper soil test. The soil test results will provide an inventory of the soil fertility upon which a nutrient strategy can be based. Directions for soil sampling and fertilizer recommendations for alfalfa and other forages are found in Manitoba Agricultures' *Soil Fertility Guide*.

Fertilizing at Establishment (New Stands)

Newly planted alfalfa needs a readily available supply of phosphorus, potassium and other plant nutrients immediately after emergence. However, high rates of fertilizer placed with the seed during seeding will damage the seedlings. Fertilizers applied at seeding should be placed at a distance from the seed to avoid seedling damage, but near enough to be effective. If machinery for accurate placement of fertilizer is not available, the fertilizer may be banded prior to seeding, or broadcast and incorporated three to four inches (7.5 to 10 centimetres) into the soil during seedbed preparation.

Phosphorus is the most important nutrient to apply at seeding time for alfalfa. The use of phosphorus fertilizer increases seedling vigour. Applying 30 pounds/acre (33 kilograms/hectare) during seeding has been shown to increase seedling size by four times compared to no phosphorus application. The best response to phosphorus is obtained when it is banded one inch (2.5 centimetres) directly below the seed.

Good response is also obtained when the phosphorus is placed one inch (2.5 centimetres) below and one inch (2.5 centimetres) to the side of the seed. Research has shown that banding phosphorous can double the seedling size within 30 days of emergence compared to a broadcast application. Placing the phosphorus greater than one inch (2.5 centimetres) to the side of the seed, or broadcasting and incorporating it into the soil, reduces its effectiveness to the new seedling.

Potassium stimulates nitrogen fixation in the plant and improves the ability of a young seedling to survive the winter. It is especially important on coarse-textured soils. Since alfalfa produces its own nitrogen, nitrogen fertilizer application is not necessary and not recommended when establishing a crop.

Seed Inoculation

Alfalfa seed should be inoculated with an appropriate Rhizobium bacteria strain prior to seeding. Inoculation enhances nodule development and nitrogen production of the plant.

Top five things you need to know about Rhizobia inoculants:

- *Rhizobia* in inoculants are a living organism with a lifespan. They should be stored in a cool dry place.
- Inoculated seed should also be stored in a cool dry place and seeded as soon as possible.
- Nodules developed from pre-existing Rhizobium in the soil fix less nitrogen than freshly applied
- Inoculants are host-specific; therefore, alfalfa inoculants will not fix nitrogen for any other legume plant.
- Check your alfalfa crowns for nodules. The goal is to have clusters of large nodules around the crown area and lateral roots with pink to red insides. Creamy, white insides indicate immature nodules, and pale green indicates unhealthy nodules. The number of nodules and the rate of N-fixation peaks just before bloom.

Seed treated on the farm should be seeded within 24 hours. Pre-inoculation of alfalfa seed by seed retailers has largely been successful and ensures growers that each seed is treated. These treatments are often applied with polymer coatings that allow longer storage periods than those for seed treated on the farm.

Fertilizing Established Stands

Even though alfalfa responds well to fertilizer, only about one-quarter of the province's alfalfa acreage receives any fertilizer. Fertilizing can pay big dividends in yield and forage quality. In research trials, the addition of fertilizer to recommended levels on established stands increased the yield of alfalfa forage by 39, 27, and 38 per cent for the first, second and third cuts respectively on clay loam soils. On sandy loam soils, the increases were 300 per cent for the first and second cuts. Without fertilization there was no third cut. Adding fertilizer also increased the protein content of the alfalfa substantially.

A high-yielding crop of alfalfa uses a tremendous amount of plant nutrients. In trials, it was determined that a 5.5 tons/acre (13.6 tonnes/hectare) crop of alfalfa used about four times as much nitrogen, twice as much phosphorus and sulphur and six times as much potassium as a 40 bushel/acre (2.7 tonnes/hectare) crop of wheat. This large removal of nutrients from the soil by alfalfa makes it essential to monitor the soil fertility and forage nutrient composition annually by soil and plant analysis.

Nitrogen (N)

Alfalfa is a legume. Legumes co-exist with Rhizobium bacteria which form nodules on the roots of the plant. In the nodules, the bacteria convert atmospheric nitrogen into a form which is useable by the plant – a process called nitrogen fixation. The Rhizobium are applied to the seed through an inoculant. Under proper management, alfalfa derives most of its nitrogen from nitrogen fixation. Nitrogen is also added to the soil by the plant. The amount of nitrogen added to the soil is approximately three per cent of legume dry matter produced. The application of nitrogen fertilizer to alfalfa crops is not recommended.

When high rates of manure are applied to an alfalfa crop, the plant may use the nitrogen available from the manure instead of fixing nitrogen from the air. This can lead to reduced plant competitiveness, especially when grown with aggressive grasses.

Phosphorus (P)

The majority of Manitoba soils are deficient in plant- available phosphorus. An annual broadcast application of phosphate is usually necessary to maximize forage yields. Table 1 illustrates the benefit of annually applying commercial phosphate fertilizer (P_2O_5) to soils with low levels of plant-available phosphorus.

Table 1. Effect of phosphorus on alfalfa yield, phosphorus content and protein content

Rate of P_2O_5 (lb/ac)	Yield (ton/ac)	Plant Phosphorus content (%)	Plant Protein content (%)
0	2.2	0.08	11.3
20	2.7	0.15	12.5
40	4.5	0.20	13.8
60	5.6	0.22	20.0
100	5.0	0.25	18.8

Data from five station-years on three Manitoba soils.
Initial soil phosphorus levels were 3.5 to 11 ppm.
Plots also received 30 lb/ac of potassium and 30 lb/ac sulphur annually.

Phosphorus management in established stands may have environmental consequences. Perennial crops such as alfalfa forage are known to minimize phosphorus losses due to soil erosion of particulate phosphorus (insoluble phosphorus held on soil particles). However, spring snowmelt from forage fields appears to be a contributor of phosphorus to Manitoba waterways, carrying dissolved phosphorus from the soil surface and a portion of that contained in unharvested plant material. There are a number of practices offering some potential for reducing this risk of loss.

- Timing the application of phosphorus fertilizer or manure immediately following the first cut harvest will provide more time for the phosphorus to react with the soil and for plant uptake before the following spring runoff.

- Subsurface placement of phosphorus into established stands with coulter or spoke-application would reduce P concentrations at the soil surface but must be done without damaging alfalfa crowns or roots.

- Plant material contains phosphorus. Removal of plant material in the fall may also need to be considered if the area is subject to runoff, since phosphorus content of unharvested regrowth can be substantial (Table 1). However, the risk of reduced snow catch and subsequent winterkill of the crop may make this practice unacceptable.

- Soil testing should be done to ensure phosphorus application rates are not excessive.

Potassium (K)

An adequate supply of available potassium will stimulate nitrogen fixation in alfalfa. Most Manitoba soils contain enough potassium for alfalfa production. Soils most likely to be low in potassium are sands and sandy loam soils (Figure 1). Research has shown that on sandy loam soils, both the yield and the potassium and protein content of the forage increased with increasing rates of potassium (K_2O) applied (Table 2).

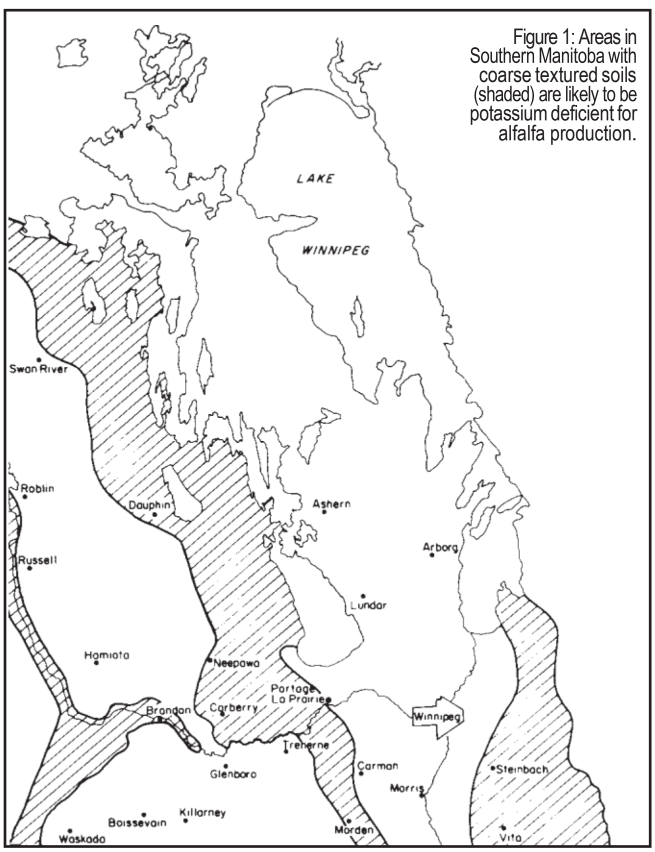

Figure 1: Areas in Southern Manitoba with coarse textured soils (shaded) are likely to be potassium deficient for alfalfa production.

Table 2. Effect of potassium fertilizer on alfalfa yield, potassium content and protein content

Rate of K_2O (lb/ac)	Yield (ton/ac)	Potassium %	Protein (%)
0	1.5	0.8	9.4
50	2.8	1.2	12.5
75	3.7	1.8	17.5
100	4.7	2.5	20.0
200	4.4	3.2	21.2

Data from five station-years on three Manitoba soils.
Initial soil potassium levels were 14 to 180 ppm.
Plots also received 60 lb/ac phosphorus and 30 lb/ac sulphur annually.

When alfalfa is grown on soils low or deficient in potassium, winter injury can be severe, and the life of the stand decreased. Potassium enhances winter hardiness and early spring growth of the plants. Figure 2 shows the effect of potassium fertilization on preventing winterkill of alfalfa on a sandy loam soil over an eight-year period.

Potassium may be taken up by alfalfa in large amounts when present at high levels in the soil or as applied nutrients. Excessive forage potassium levels in alfalfa forage (greater than three per cent) can cause milk fever and related health problems (including swelling of the udder) in dry cows prior to calving.

Stand density vs. previous fall

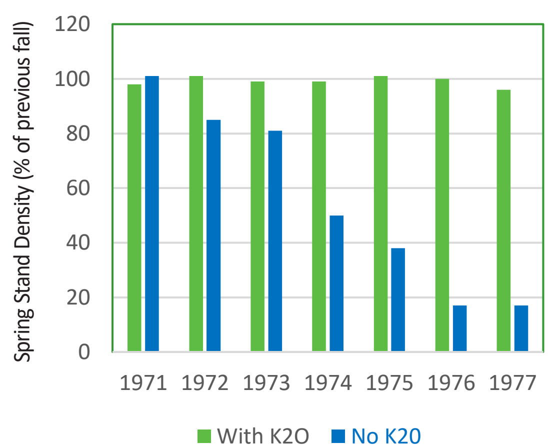

Figure 2. Effect of potassium fertilizer in protecting alfalfa from winterkill on a sandy loam soil. Stand density is the number of surviving plants in May expressed as a percentage of the same count taken the previous September

Sulphur (S)

While sulphur deficiencies can occur in any soil, soils on which sulphur deficiency is most likely include well-drained sandy soils and the grey wooded soils. Grey wooded soils are found at the higher elevations in the province such as the Turtle, Duck, Riding, and Porcupine mountains. Soil testing is recommended to establish the available sulphur status of the soil.

Alfalfa crops have a higher demand for sulphur than annual crops such as cereals and flax. Sulphur is important in the production of protein by legume crops.

Sulphur fertilizer recommendations are based on sulphur being applied in the sulphate form since it is the only form readily available to plants. Table 3 shows the effect of annual application of sulphur (S) on a sulphur-deficient grey wooded soil.

Sulphur in the elemental form is not available for plant uptake until it is converted to the sulphate form in the soil, a process which can take time. Therefore, some high-analysis sulphur products containing elemental sulphur are not recommended for use where the crop requires the sulphur to be available in the year of application. If elemental sulphur is being applied on an annual basis to an alfalfa crop, the soils should be tested annually in order to ensure supplies of sulphur are adequate for maximum production.

Tissue Sampling

Tissue sampling may help identify any nutrient deficiency in a crop but is particularly useful for micronutrients. Soil testing for micronutrients is generally not as reliable as for other nutrients, so tissue sampling is recommended. Table 4 contains the guidelines used to determine nutrient deficiencies.

Micronutrients

Most Manitoba soils contain enough micronutrients for alfalfa production. Before applying a micronutrient fertilizer, it should be established that a deficiency exists, either through a tissue analysis of the growing alfalfa plant and/or observation of visual deficiency symptoms. The micronutrient most likely to be lacking in Manitoba is boron. Deficiencies may occur on sandy, low organic matter, high pH soils under dry conditions.

Sufficient levels of boron are usually mineralized from soil organic matter, but this mineralization is reduced under dry soil conditions. Visual symptoms are most commonly observed in the regrowth after the first cutting. Effected plants may be stunted with reduced internode growth and purple to yellow leaves.

Table 3. Effect of sulphur fertilizer on alfalfa yield, suphur content and protein content of alfalfa.

Rate of S (lb/ac)	Yield (ton/ac)	Plant Sulphur %	Plant Protein (%)
0	1.6	0.10	8.8
15	2.8	0.16	11.3
30	4.3	0.21	18.8
45	5.3	0.23	20.6
60	5.2	0.23	21.3

Data from five station-years on three Manitoba soils.
Initial sulphur contest was 13 lbs/ac..
Plots also received 60 lbs/ac of phosphorus and 30 lb/ac potassium annually.

Table 4. Plant tissue analysis criteria for alfalfa (top 6” taken at flowering).

NUTRIENT	% CONTENT				
	RATING				
	Low	Marginal	Sufficient	High	Excess
Nitrogen % N	1.9	2.0 - 2.4	2.5 - 4.9	5.0 - 6.9	7.0
Phosphorus % P	0.19	0.20 - 0.24	0.25 - 0.69	0.7 - 0.99	1.0
Potassium % K	1.74	1.75 - 1.9	2.0 - 3.4	3.5 - 4.9	5.0
Sulphur % S	0.19	0.20 - 0.24	0.25 - 0.49	0.5 - 0.79	0.8
Calcium % Ca	0.24	0.25 - 0.49	0.5 - 2.9	3.0 - 3.9	4.0
Magnesium % Mg	0.19	0.2 - 0.29	0.3 - 0.99	1.0 - 1.9	2.0
Zinc ppm (Zn)	11	12 - 19	20 - 69	70 - 99	100
Copper ppm (Cu)	3	4 - 7	8 - 29	30 - 49	50
Iron ppm (Fe)	19	20 - 29	30 - 249	250 - 499	500
Manganese ppm (Mn)	14	15 - 24	25 - 99	100 - 299	300
Boron ppm (B)	19	20 - 29	30 - 79	80 - 99	100
Molybdenum ppm (Mo)	0.4	0.5 - 0.9	1.0 - 4.9	5.0 - 9.9	10

Although this tissue analysis criteria is based on specific sampling at growth stages and timing, the results from a feed test may help indicate what nutrients are lacking. A soil test is required to determine the amount of nutrient required.

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