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Fertilizer and Nutrient Management of Timothy Hay

Timothy has a relatively high demand for nutrients. Under excellent moisture conditions or irrigation and when supplied with the optimum nutrients, timothy is capable of producing yields in the range of 5 to 6 tons/acre, typically 3 to 3.5 tons for first cut and 1.5 to 2 tons for second. With reasonable precipitation, non-irrigated timothy will produce 2 to 4 tons/acre annually.

Table 1 provides approximate amounts of each nutrient removed per ton of timothy dry matter. Nutrients removed are not necessarily closely related to fertilizer requirements.

Table 1. Approximate nutrient removal per ton of timothy dry matter forage

Nutrient	Amount Removed (lb/ton)*
Nitrogen (N)	35.0
Phosphorus (P)	4.0
Phosphate (P_2O_5)	10.0
Potassium (K)	40.0
Potash (K_2O)	50.0
Calcium (Ca)	7.0
Magnesium (Mg)	5.0
Boron (B)	0.08
Copper (Cu)	0.01
Iron (Fe)	0.3
Manganese (Mn)	0.1
Molybdenum (Mo)	0.002
Zinc (Zn)	0.05

* Amounts of removal are approximate and vary depending on growing season conditions

Soil testing

Soil testing is the most reliable method of evaluating nutrient deficiencies and should be the starting point for making soil fertility and fertilizer management decisions. A balanced fertilization program based on careful soil sampling and testing should be planned before seeding timothy.

If a field has different soil types or eroded areas, these areas should be sampled separately, as they likely will require different fertilizer management and often need higher amounts of phosphate fertilizer.

Most grass fertility research shows that balanced fertilizer application (according to soil test results) gives greater returns than using nitrogen alone. Special attention should be paid to nitrogen (N), phosphorous (P), potassium (K) and sulphur (S) to determine which nutrients are deficient or marginal. Then, determine the form and rate of each fertilizer needed.

General nutrient requirements

Nitrogen (N)

Nitrate nitrogen (NO_3), the form of N taken up by timothy, is often the major limiting nutrient in timothy hay production. Almost all the N stored in the soil is contained in soil organic matter. One per cent soil organic matter contains approximately 1,000 lb N /ac. Therefore, a dark brown soil with an organic matter content of 4 per cent would contain about 4,000 lb N/ac. However, only a very small amount (less than 1 per cent) would be released through breakdown each year. The breakdown is called "mineralization," and the process is carried out by soil micro-organisms.

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Microbial activity by these micro-organisms is influenced by a number of environmental conditions; the most important are soil temperature, soil moisture and organic matter content. Normally, only 10 to 30 per cent of the total N required for optimal timothy yields is supplied by N released from soil organic matter decomposition. The rest must be supplied by fertilization.

Top dressing N fertilizer (fertilizer broadcast onto the soil surface) is the most common way to apply nitrogen to established forage stands. The effectiveness of the application is reduced when moisture is insufficient to move the N into the soil, to the root zone.

The most common and effective granular N fertilizer for broadcast application onto timothy was ammonium nitrate (34-0-0). However, this fertilizer product is no longer manufactured in Canada. It is rarely available to farmers in western Canada, except if specifically imported.

Urea (46-0-0) is now the most popular source of granular N fertilizer used for application onto timothy, mainly due to price and availability. Central Alberta studies have shown late fall or early spring applications are efficient, and losses due to volatilization (N lost to the atmosphere when urea converts to gaseous ammonia) are generally low.

A recent irrigated research study in southern Alberta has also shown that urea applied in very early spring can be very effective. However, if urea is broadcast in warm conditions or onto higher pH soils, volatilization losses of N can be high when soil temperatures are greater than 5°C and air temperatures are greater than 10°C.

Several new products are available that provide protection from volatilization of urea fertilizer. A urease inhibitor product, Agrotain, is commercially available to coat urea before broadcast application. This product works by protecting the fertilizer granules from the enzyme urease, which acts to break down the urea fertilizer. Agrotain is a urease inhibitor that protects the fertilizer from breakdown for 10 to 12 days.

A polymer coated urea (45-0-0) product called ESN (Environmentally Sustainable Nitrogen) is also available. However, irrigated trials with this product in southern Alberta have shown that the broadcast polymer coated urea releases too slowly to be effective and, therefore, is normally not recommended for broadcast application.

Nitrogen may be applied in single or split applications depending on yield potential, soil type and if the crop is irrigated. Split rate applications are strongly advised in a two-cut system where recommended N rates exceed 60 lb/ac.

Phosphorus (P)

Timothy requires adequate soil phosphorus (P) levels. Phosphorus is very important because it prolongs stand life and increases the efficiency of plants using other nutrients and water.

When soil P level is low, crop growth, yield and quality are reduced. Most western Canadian soils are naturally low in plant-available P. However, fields that have received either repeated phosphate fertilizer or manure application regularly for a number of years may have adequate soil P levels.

Residual soil P levels will vary with past fertilizer management history. For this reason, soil sampling is an essential part of the soil fertility management program.

In the past, a standard recommendation for phosphate fertilizer has been to apply a significant amount of P fertilizer prior to the establishment of timothy. For example, a 3 ton/ac crop requires approximately 30 to 35 lb of phosphate (P_2O_5)/acre. A 150 lb/ac application of P_2O_5 before a timothy field is established would meet crop requirements for about four to five years.

However, recent research in southern Alberta has shown that early spring annual broadcast application of P fertilizer with irrigated timothy has resulted in the most effective P fertilizer response.

Some Manitoba soils are capable of tying up P; therefore, large batch applications of phosphate fertilizer are generally not recommended in that province. Annual applications of P_2O_5 are recommended instead. However, some Manitoba producers report good results with batch applications of P when it is banded.

Ideally, growers should consider both a large batch application of P fertilizer just prior to crop establishment and a modest rate of broadcast P fertilizer as early as possible each spring.

Potassium (K)

Timothy has a large requirement for potassium for healthy crop growth, standability and winter survival. Potassium deficiencies are most common on well drained, coarse-textured soils (sandy soils, Gray Wooded soils and Gray-Black transition soils). A soil test is the best way to determine if potassium is required. The use of a potash fertilizer test strip can be helpful to determine if K fertilizer is needed.

Highly productive forage stands can quickly mine this nutrient down to a deficient level, particularly in sandy soils. Approximately 70 to 80 per cent of the potassium is taken up in the leaves and stems, which is all removed from the field when the timothy is harvested.

Sulphur (S)

The importance of sulphur (S) in a forage fertility program should not be overlooked. S deficiencies can appear in any soil that is intensively cropped or is subject to leaching. Leaching tends to be a greater concern in sandy soils and higher precipitation areas.

Sulphur deficiencies are most common in Black and Gray Wooded soils. Deficiency is rare on irrigated land as sulphate-sulphur occurs naturally in irrigation water. Timothy, being somewhat shallower rooted than other grasses, is one that may respond to S fertilizer application. S deficient crops will appear pale in colour, similar to a deficiency in N.

For optimum utilization of N fertilizer, it is important that a 10-to-1 ratio of N to S be available on sulphur deficient soils. Nitrogen and S combine to form amino acids, the building blocks of protein. When there is insufficient S to convert the absorbed N into protein, a buildup of non-protein N (N-P-N) can occur. Large amounts of N-P-N will disrupt functions within the plant. High nitrate levels in plants are also a concern when the plants are fed to livestock.

Plants take up S in the sulphate (SO_4-S) form. If soils are deficient in S, then ammonium sulphate is the best product to use. In situations where a producer wants to build sulphate S levels in soil, elemental S fertilizer can be used. To be effective, the elemental S fertilizer must oxidize by combining with oxygen and water to oxidize to sulphate S. However, this process can be a long one, and the elemental S fertilizer should be applied prior to stand establishment.

The elemental S should be surface broadcast in the fall; the S granules must disperse over winter, and then, the S fertilizer should be well incorporated the following spring, prior to stand establishment. For general maintenance of S levels in the soil, elemental S is the more economical choice, but it requires careful management to be effective.

As mentioned, irrigated soils are rarely deficient in S because irrigation water in southern Alberta naturally contains dissolved sulphate S, which is the form plants require. Approximately 30 lb/ac of SO_4-S is added to soil with every 12 inches (300 mm) of irrigation water applied, which is ample to meet timothy requirements.

Micronutrients

Micronutrients are required in relatively small amounts by timothy and are essential to crop growth and quality. The extent of micronutrient deficiency in timothy production is unknown in western Canada as there has been little micronutrient research. Producers who feel they are reaching a maximum yield potential for their land should consider a complete soil test, including micronutrients to ensure there is no deficiency.

A number of reasons are behind the growing importance of ensuring adequate levels of micronutrients are available for the crop. Although little micronutrient research work has been conducted with forage crops, deficiencies in boron or copper could pose problems in the future, particularly on sandy, intensively cropped soils. Boron deficiencies could occur on sandy, low organic matter soils. Copper deficiencies occur in the Black or Gray-Black transition soils that are coarse textured with relatively high levels of organic matter (6 to 10 per cent).

Extreme care is required when applying micronutrients. Micronutrients, such as boron, can be toxic to timothy as well as other crops. Micronutrient fertilizers are not recommended without first conducting a soil fertility test and consulting a soil or forage specialist.

Nutrient management in the establishment year

The establishment of a high yielding, pure timothy stand requires careful attention prior to seeding. Always use soil tests to determine nutrient requirements before establishment.

Remember that timothy seed has very little tolerance to seed-placed fertilizers, particularly N. Levels of 30 lb/ac of N in urea form with the seed have reduced stands by 30 to 35 per cent. It is recommended that all fertilizer be broadcast and incorporated or banded at 2 to 3 inches (5 to 7.5 cm) deep prior to seeding. Seed-placing fertilizer can increase risk and reduce stand establishment.

A wise practice for most areas is a 150 lb/ac application of P_2O_5 before a timothy field is established, which would meet crop requirements for about five years.

Nutrient management in established timothy

This guide and similar production publications treat nutrients as individual entities. Remember, however, that crops, like livestock and people, require balanced nutrition.

Nitrogen

N fertilizer requirements should be based on the soil test level of nitrate-nitrogen (NO_3-N). Under normal growing conditions, an established grass stand in the spring usually has very low levels of plant-available NO_3-N.

The lower the level of available soil N, the greater the need for N fertilization. Timothy will respond dramatically to N fertilizer on deficient soils. Under higher moisture conditions, high rates of N fertilizer are economical. However, high rates should only be applied when soil test NO_3-N levels are very low and moisture conditions are very good.

Nitrogen should be broadcast on timothy as early as field conditions allow in the spring, prior to active growth. Late fall applications of N are not recommended to avoid fertilizer N losses.

Nitrogen fertilizer requirements for first-cut timothy should be applied as early as possible in spring, before timothy begins active growth. If more than one cut is planned, apply second-cut N requirements immediately after the first cut.

Annual N applications are required for optimum hay production. Excessive amounts of N on timothy will increase lodging, browning of leaves and disease. General N fertilizer recommendations are provided in Table 2.

Phosphorous

If phosphate (P_2O_5) was not applied before establishment or is limiting production, a grower should consider an annual maintenance application of 20 to 50 lb/ac of P_2O_5 to replace crop removal rates. Phosphorus in soil is quite immobile and moves very slowly in the soil. However, under good moisture conditions, timothy has feeder roots near the soil surface and can take up P with reasonable efficiency.

An irrigated research study in southern Alberta showed that annual early spring broadcast application was very effective and was superior to a one-time only application of P fertilizer at the time of establishment. Early spring shallow banding of P fertilizer into an established stand was also less effective than an early spring broadcast application of P fertilizer.

General broadcast P fertilizer recommendations are shown in Table 3.

Table 2. General nitrogen fertilizer recommendations (lb N/acre) for early spring application for first-cut timothy in various soil areas in Alberta with medium soil moisture conditions and normal precipitation

Soil test N	Soil test areas					
(lb/ac in 0-24 in)	Irrigated	Brown	Dark Brown	Thin Black	Black	Dark Gray & Gray Wooded
	Total N fertilizer required (lb/ac)					
0	150	70	80	100	120	110
10	140	60	70	90	110	100
20	130	50	60	80	100	90
30	120	40	50	70	90	80
40	110	30	40	60	80	70
50	100	20	30	50	70	60
60	90	10	20	40	60	50
70	80	10	10	30	50	40
80	70	–	–	20	40	30
90	60	–	–	10	30	20
100	50	–	–	–	20	10
110	40	–	–	–	–	–
120	30	–	–	–	–	–

Table 3. Phosphate fertilizer recommendations for timothy based on the Kelowna soil P test method						
(lb/ac in 0-24 in)	Irrigated	Brown	Dark Brown	Thin Black	Black	Dark Gray & Gray Wooded
	Total N fertilizer required (lb/ac)					
0-10	60	35	40	45	50	45
10-20	50	25	30	35	40	35
20-30	45	15	20	25	30	25
30-40	40	15	15	15	20	15
40-50	35	15	15	15	15	15
50-60	30	15	15	15	15	15
60-70	25	0	0	0	0	0
70-80	20	0	0	0	0	0
>80	0	0	0	0	0	0

Potassium

In fields testing deficient in K, annual applications of potash fertilizer (K_2O) may be necessary, and the soil test recommendation should be followed (Table 4).

Fields with sufficient K soil levels (>225 lb k/ac) will occasionally respond to a 50 lb/ac application of K_2O fertilizer in early spring, particularly under unseasonably wet and cool weather conditions. Under these conditions, soil K is less available and less mobile in the soil. As responses to K_2O are not common, applications should first be tried in carefully marked test strips.

Table 4. Potassium fertilizer recommendations for timothy, based on the ammonium acetate soil K test method	
Soil test potassium (K) (0-6 inch depth)	Recommended potash (K_2O) (lb/ac)
0-25	160
25-50	145
50-75	125
75-100	110
100-125	90
125-150	75
150-175	55
175-200	40
200-225	20
>225	0

Sulphur

A soil test for S can help determine if S fertilizer is needed. However, soil testing for S can be quite variable across fields. Therefore, different topographic or landscape areas may have to be sampled separately. Samples should be taken separately from the 0 to 6, 6 to 12 and 12 to 24 inch depths (0 to 15 cm, 15 to 30 cm and 30 to 60 cm). Table 5 may be used as a guide to decide if S fertilization is required.

Table 5. Sulphur fertilizer recommendations for timothy	
Soil test level SO_4-S (lb/ac) (0-12 inch depth)	Recommended sulphur (lb/ac)
0-5	20
5-10	15
10-15	10
15-20	5
>25	0

Fertilizing with manure

Using manure to fertilize established timothy fields is normally not recommended. If this method is used, caution is necessary. To produce high yields, timothy needs an abundant supply of inorganic N early in the spring. Since much of the N in manure is in the organic form, it may not be released until later in the spring and summer.

More importantly, manure has the potential to cause leaf burn and could be a source of additional weeds. Unless the amount of available N is known, high rates of manure could cause excessive growth, which will result in a lodged crop and greatly reduced quality.

For these reasons, manure is best used on non-legume and annual crops. If no other land is available to spread manure, then use the field with the oldest forage stand. Solid manure should be well broken up and applied at a

rate no higher than 10 tons/acre in early spring or immediately after harvest. This approach ensures that most of the manure comes into contact with the soil, not the crop.

Plant tissue analysis

Plant tissue analysis can provide useful information on soil fertility and the crop's nutritional health. In timothy, tissue analysis can determine the nutritional levels of the crop before visual deficiency symptoms appear. Tissue analysis, coupled with soil tests, can make for a more comprehensive fertilizer management program in established timothy stands.

For optimum production, timothy plants just prior to heading should contain a minimum of 2 per cent N, 0.20 per cent P, 1.5 per cent K and 0.1 per cent S. Table 6 provides approximate levels of each nutrient in the whole, aboveground plant prior to seed heading. The best time to tissue sample is just before timothy has headed.

Table 6. Levels of nutrients in the whole plant timothy tissue before heading

Nutrient	Low	Sufficient	High
	Per cent (%)		
Nitrogen	<1.8	2.0-3.0	>4.0
Phosphorus	<0.15	0.25-0.50	>0.80
Potassium	<1.0	1.50-3.0	>5.0
Calcium	<0.15	0.20-0.50	>1.0
Magnesium	<0.10	0.15-0.50	>1.0
Sulphur	<0.10	0.15-0.40	>0.80
	Parts per million (ppm)		
Boron	<3	5-25	>75
Copper	<2	5-25	>50
Iron	<15	20-250	>500
Manganese	<10	15-100	>250
Zinc	<10	15-70	>150

To sample: randomly select about 35 to 40 plants across a typical area. Cut off just above ground level. Always sample poor growth areas separately from normal growth areas. Air dry samples and forward to a laboratory for analysis.

Fertilizer products

The selection of fertilizer types for timothy should be governed by availability, product type, application method, nutrient cost per unit and relative product convenience.

Nitrogen (N): Urea (46-0-0): This is the highest analysis granular product. It is generally the least expensive. When surface applied, urea can change to gaseous ammonia and be lost to the air (volatilization) under certain conditions. For this reason, applications of urea should be timed when temperatures are cool; for example, air temperatures should be less than 10 C° (50 F°) and soil temperatures less than 5 C° (40 F°).

Ammonium nitrate (34-0-0): This fertilizer product is no longer manufactured in Canada but is occasionally imported into Alberta. It contains half of its N in the mobile nitrate form, which is plant available, and half in ammonium form, which is not mobile. This feature can be an advantage when rapid N uptake is important. It can safely be broadcast onto established stands without volatilization losses. Southern Alberta research has shown that urea and ammonium nitrate can be equal in effectiveness as sources of N for timothy, providing volatilization losses are minimal.

Liquid Fertilizer: Urea-ammonium nitrate (UAN) liquid fertilizers (28-0-0, etc.) contain urea and ammonium nitrate dissolved in water. Liquid N fertilizers are normally equally effective as the two granular N fertilizers. However, simply because the N is dissolved in water does not mean the N is more available to the crop. Urea in liquid fertilizer is subject to the same volatilization losses as granular urea. Therefore, it must be managed carefully to prevent gaseous loss. Liquid fertilizers used at higher rates can also cause burning of plant tissue.

Liquid fertilizers are very useful and convenient for irrigated timothy producers because less time and labor are required if the producer has the necessary injection and tank equipment for fertigation. Spraying liquid fertilizer onto timothy can be effective, but can result in leaf burn at rates of greater than 20 lb N/ac when applied onto growing plants.

Phosphorous (P): Commercial granular phosphate fertilizer is monoammonium phosphate. It contains 11 to 12 per cent N and 51 to 55 per cent phosphate (P_2O_5). Commercial liquid phosphate fertilizer is ammonium polyphosphate. It usually contains 10 per cent N and 34 per cent phosphate (P_2O_5). Ammonium phosphate is the fertilizer form. The liquid polyphosphate (10-34-0) is applied in a solution form. Both fertilizer types release rapidly in the soil to available P forms and are equally effective.

Potassium (K): The most commercial potassium fertilizer sold is potassium chloride (KCl) and is often referred to as muriate of potash. Potassium chloride (0-0-60 or 0-0-62) is the common form used as fertilizer.

Sulphur (S): Fertilizer containing sulphate-sulphur, like ammonium sulphate [21-0-0-(24)], which contains 24 per cent SO_4-S, is best if S is deficient in soil. Fertilizer containing sulphate is immediately available to the crop. Other fertilizers that contain elemental (pure) sulphur (S°) (0-0-0-90), or urea sulphur [34-0-0-(20)] are recommended if S levels need to be built up over time.

Elemental sulphur must be converted by micro-organisms to the sulphate form before being taken up by the crop. Conversion to sulphate requires many months to several years under warm, moist conditions. In most cases, when elemental S° is applied to established timothy, conversion to sulphate is too slow to satisfy crop requirements on deficient soils.

Micronutrients: For specific information on micronutrient requirements, fertilizer sources and methods of application for timothy production on problem soils, consult a soil or forage specialist.

Scientific reference

McKenzie, R. H., Bremer, E., Pfiffner, P. G., Middleton, A. B., Dow, T., Oba, M., Efetha, A. and Hohm, R. 2009. Yield and quality responses of irrigated timothy to fertilizer application in southern Alberta. Can. J. Plant Sci. 89: 247-255.

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