PEI Soil and Crop Improvement Association Conference

Growing Forage in a Changing Climate

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Credit Union Place, Summerside, PEI
March 5, 2020


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A big part of being successful in the beef, sheep and dairy industries **is producing a competitive feed package**

Cost Efficient
Feed Efficient

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Three Pillars of Forage Production

The basis of a profitable feed package

Yield
Persistence (stand longevity)
Quality

Your primary goal as a forage producer is to obtain a good yield of quality feed while allowing for stand persistence.

Secondary goals include improvement in soil quality, increased soil carbon sequestration and ecosystem services.

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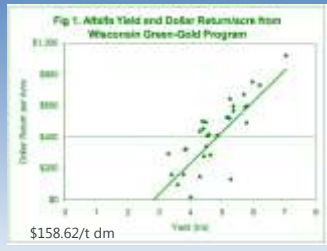
Yield is Number #1

Yield has the largest impact on forage profitability because input costs, including harvesting costs, change little as yield increases.



"Team Forage" at the University of Wisconsin states; yield is the single most important factor determining profit. The relationship is so strong that farmers should do all they can to remain in the high yield range with their alfalfa." **Dan Undersander**[1] and **Ken Barnett**[2]

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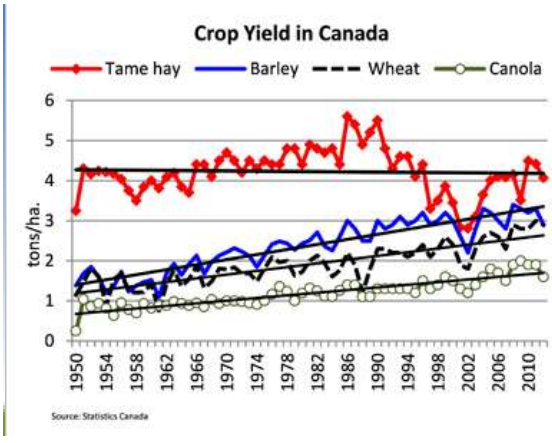

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Climate Change

Mean Daily Temperatures in Charlottetown

Season	Historical 1980s	Projected 2020s	Projected 2050s	Projected 2080s
Winter	-4.1°C	-2.9°C	-1.5°C	-0.2°C
Spring	4.2°C	5.1°C	6.2°C	7.4°C
Summer	16.9°C	17.9°C	19°C	20.1°C
Autumn	8.8°C	9.8°C	11°C	12.2°C
Annual	6.4°C	7.5°C	8.7°C	9.9°C

The temperature has already raised an average 1.6 °C between 1948 and 2013, and yearly precipitation has increased over 200 mm. The region is looking at even warmer/wetter winters and hotter, drier summers in the future.

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The expected cropping risks associated with climate change are extended dry periods, severe weather systems and winterkill.

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The expected cropping risks associated with climate change are extended dry periods, severe weather systems and winterkill.

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The major environmental stresses resulting in winter injury and kill are cold temperatures, fluctuating temperatures, ice sheeting and excess soil moisture

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Managing Forage Stands to Minimize Winter Injury

With climate change the risk of forage stands being injured or killed by cold temperatures, fluctuating temperatures, ice sheets and heaving is expected to **increase.**

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Exposure to Subfreezing Temperatures

The capacity to tolerate cold temperatures is probably the single most important factor influencing plant winterhardiness.

Alfalfa can tolerate a mild freeze of about -5^0 C during summer, but it can withstand winter temperatures of -15 to -20^0 C after a fall acclimation period.

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Preparing for Winter –Hardening Off

Plants prepare for winter as the days become shorter and cooler in late summer and early fall.

Once night time temperatures drop below 5^0 C the plant truly begins the process of winter hardening.

Preparing for cold temperatures

1) Cell membranes become less rigid
2) Sugars accumulate within the cells to lower freezing point.
3) Most important the cell loses water. The water located in the cell walls and outside the cells freezes. This does not damage the cells but pulls even more water out of the cells. The cell becomes dehydrated leaving very little water in the cell to freeze and damage the cell.

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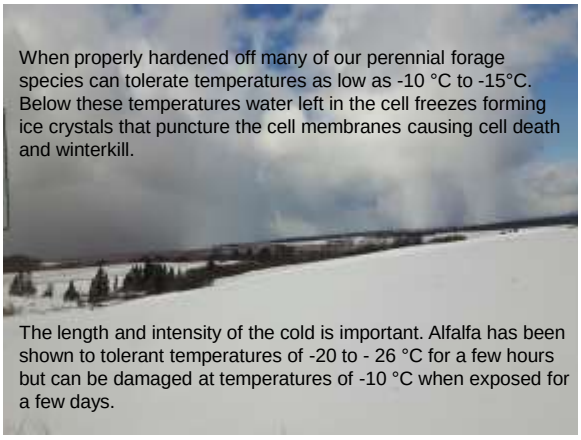

When properly hardened off many of our perennial forage species can tolerate temperatures as low as -10 °C to -15°C. Below these temperatures water left in the cell freezes forming ice crystals that puncture the cell membranes causing cell death and winterkill.

The length and intensity of the cold is important. Alfalfa has been shown to tolerant temperatures of -20 to - 26 °C for a few hours but can be damaged at temperatures of -10 °C when exposed for a few days.

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Forage Species (Grasses) Differ in their Ability to Withstand Cold Temperatures

Comparison between Grass Species for Cold Hardiness
B.E. Gudleifsson et al. 1986

	Cold Hardiness
Species	LT_{50} (°C)
Reed canarygrass	-5.7
Orchardgrass	-9.0
Meadow Fescue	-10.9
Meadow Foxtail	-11.1
Kentucky Bluegrass	-13.6
Timothy	-14.4

Cold Tolerance and Ice Tolerance of Pasture Grasses Grown and tested in Controlled Environments Can. J. Plant Sci. 66: 601-608

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Capacity to Tolerate Winter Conditions

Grasses	Legumes
• Timothy -VG	• Birdsfoot Trefoil – G
• Bromegrass -VG	• Alfalfa -G
• Reed Canarygrass –G	• Red Clover –G
• Tall Fescue – F-G	• White Clover –P
• Meadow Fescue F-G	
• Orchardgrass - F	
• Festiloliums -F	
• Perennial Ryegrass -P	

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"Case in Point"

One of the most severe winter kill events in PEI history (1972) was attributed to a prolonged period of subfreezing temperatures at soil level. Red clover sustained the greatest losses, followed by alfalfa and orchardgrass. Birdsfoot trefoil and smooth bromegrass suffered less damage while timothy was relatively unaffected. (Suzuki 1972)

Winterkill patterns of forge crops and winter wheat in PEI in 1972. Can. Plant Dis. Surv. 52: 156-159 Suzuki M.

A layer of snow can adequately insulate the soil and prevent direct freezing damage.

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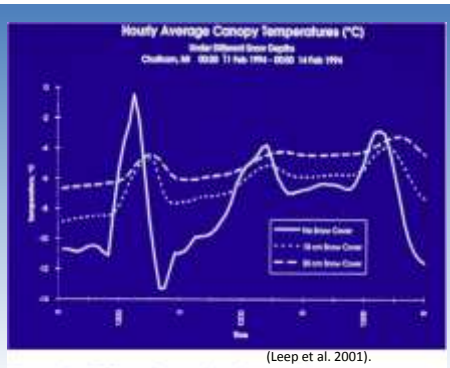
A minimum 10 cm of snow is considered adequate to insulate the soil and prevent direct freezing damage



(Leep et al. 2001).

Figure 1. Effect of snow depth on soil temperature.

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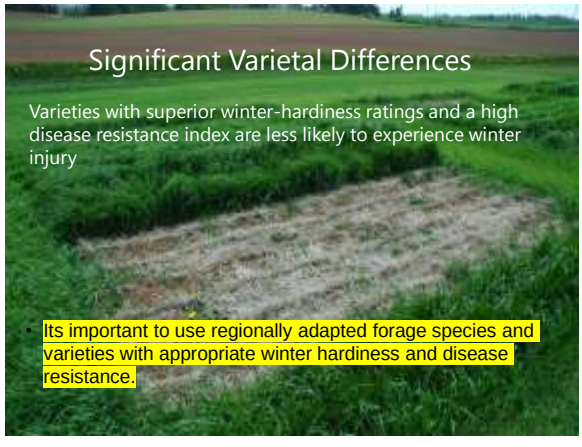

Significant Varietal Differences

Varieties with superior winter-hardiness ratings and a high disease resistance index are less likely to experience winter injury

- Its important to use regionally adapted forage species and varieties with appropriate winter hardiness and disease resistance.

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Growing Well Adapted Varieties is Imperative

Cultivar Evaluation

The Atlantic Forage Team tested forage species for yield and persistence at 5 locations across the 3 Maritime Provinces until 2017

3rd year % Persistence data and Quality analysis

Some real improvements in alfalfa winterhardiness have been made in By AAFC for Eastern Canada

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Ice Sheeting

Here in the Maritimes precipitation and freeze–thaw cycles often lead to the formation of a layer of ice at the soil surface, or "ice sheeting". Ice provides little protection to low air temperatures.

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Ice Sheeting

If prolonged, ice sheeting can deplete soil oxygen and create toxic levels of carbon dioxide, ethanol, and methanol and lactic acid.

Where-as many of our most winter hardy grasses can endure long periods of ice encasement, legumes can endure only short periods.

For example ice sheeting lasting longer than 7 days can cause significant injury and even death to alfalfa plants (primarily through increased C02 levels).

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Forage Grasses Differ in their Tolerance to Ice Sheeting.

Comparison between Grass Species for Ice Tolerance
B.E. Gudleifsson et al. 1986

	Ice tolerance
Species	LI_{50} (days)
Reed canarygrass	26
Orchardgrass	9
Meadow Fescue	13
Meadow Foxtail	20
Kentucky Bluegrass	26
Timothy	37

Cold Tolerance and Ice Tolerance of Pasture Grasses Grown and tested in Controlled Environments
Can. J. Plant Sci. 66: 601-608

Betrand et al. (2003) observed the following tolerance differences between forage species to long term exposure to low oxygen conditions; timothy > orchardgrass > alfalfa > red clover.

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Dehardening & Climate Change

Fluctuating Temperatures

Warm soil temperatures (>0 to 5°C) can cause forage plants (alfalfa) to deharden and break dormancy. If followed by extreme cold or icy weather, severe winter injury and kill may result.

There are specie differences bromegrass >alfafa > timothy. A photoperiod component to dehardening has been observed in some species (timothy).

Seeding and 1st production year forage stands are much less susceptible to winter kill than older forage stands (Alfalfa stands that are 3 and 4 production years old).

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Soil Moisture

The amount of rain in the fall directly effects soil moisture and is directly correlated to winter survival.

Wet soils in the fall prevent plants from reaching there full hardening potential (reduction in intercellular solutes).

Soils with excessive moisture are poorly aerated, have greater soil freezing (frost heaving), and promote ice sheeting.

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Frost Heaving

Frost heaving occurs when ice layers form in wet soil (or poorly structured soil) during freeze thaw cycles (Beuselinck et al., 1994). The expanding ice layer thrusts the roots and crowns of tap rooted species, such as alfalfa above the soil surface where they are fully exposed to cold air temperatures and the desiccating action of winds.

The use of grasses (such as smooth bromegrass or timothy) with their fibrous root systems in a mixture with alfalfa can help reduce frost heaving.

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Increasing Axil Loads are a Concern

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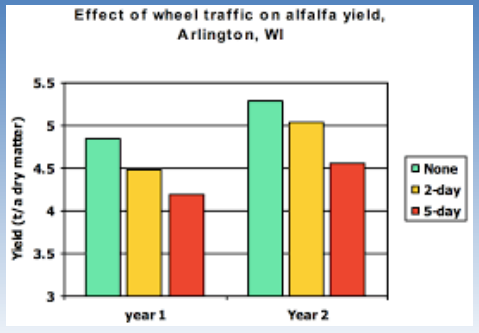

Dan Undersander, University of Wisconsin

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How Much is Grass Yield Reduced by Wheel Traffic?

% Reduction in 2nd Cut Yield to traffic injury 5 days following 1st Cut.

Forage Species	# of Cultivars under test	Average % Reduction in Yield in 2nd Cut
Alfalfa	69	11 (0-25%)
Red Clover	8	13
Tall Fescue	7	15
Orchardgrass	7	16
Reed canary	4	27
Timothy	10	32

Dr. Steve Bowley, University of Gueiph. 2003

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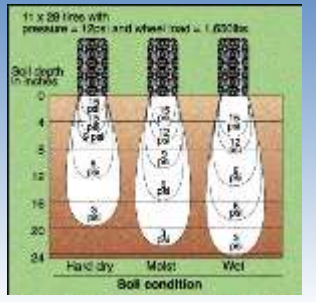
Increasing Axil Loads are a Concern

It is generally accepted that a pressure of 4 psi or more on most soils can produce compaction with economic implications. For reference, a pickup truck will impose about 50 psi pressure on the soil, a liquid manure spreader 70 to 90 psi, a 1,200-pound cow approximately 40 psi, and an all-terrain vehicle only 4 to 5 psi.



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Management Factors Influencing Winter Survival

- **Species differences**
- **Variety differences**
- **Stand age**
- **Soil moisture- too dry –too wet**
- **Soil compaction (Wheel Traffic)**

- **Cutting Management.** Both harvest frequency and timing of fall cutting affect alfalfa winter hardiness. The shorter the interval between cuttings, the greater is the risk of winter injury. Stands in which a last cutting is taken between September 1st and October 15th are at greater risk, as plants are unable to replenish root carbohydrate reserves before winter. . Take only two cuts on older stands

- **Soil pH.** Stands growing on soil with a pH greater than 6.6 are less likely to experience winter injury.

- **Soil Fertility.** Stands with high fertility, particularly potassium, are less likely to experience winter injury than those with low fertility.

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Harvest Management

Frequency of Cutting and Harvest Dates

- The shorter the interval between cuttings, the greater is the risk of winter injury. Taking only two cuts of alfalfa per season reduces the risk of winter kill especially on older stands.
- Stands in which a last cutting is taken between September 1st and October 15th are at greater risk, as plants are unable to replenish root carbohydrate reserves before winter.

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Critical Fall Rest Period

Not cutting between September 01 and October 15 (allows for 4 to 6 weeks of growth before the average date of the first killing frost). Allows the plant to build important root reserves.

Cutting during this period does not allow the plants enough time to replenish root carbohydrate reserves before winter.

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Taking a Fall Cut

In a 6 site study across Eastern Canada (Belanger et al. 1999) harvesting alfalfa in September or October increased winter damage and decreased regrowth the following spring.

If a fall cut is to be taken it is recommended that a harvest interval between the last summer cut and the fall cut be 500-600 growing degree days (5°C base)

For 2nd, 3rd and 4th harvest years don't take a fall harvest if you want to keep the stand.

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Good management can increase yield and help minimize winter kill

Not only time of harvest and harvest frequency but cutting height can serve to either maintain or deplete root reserves critical for regrowth and winter survival

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Stubble Height is Important

The stubble height to leave to optimize forage production

Forage species	Post-harvest height (inches)	
Orchardgrass	4-5	
Tall fescue & Meadow fescue	4-5	Non-jointed grasses
Bromegrass	2-3	
Timothy	2-3	Jointed grasses
Reed canarygrass	2-3	

Rayburn, E., Pasture Management for Pasture-finished Beef, March 2005.

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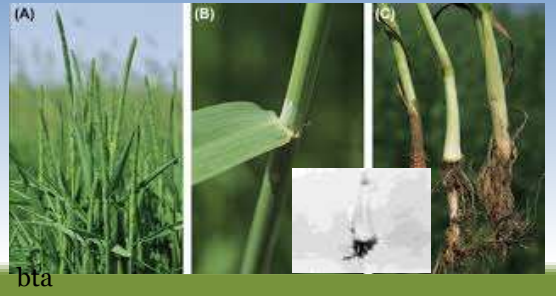
Jointed Grasses - Timothy

Jointed grasses have a high percentage of tillers that produce a seed head/low number of vegetative tillers and have "jointed" aftermath shoots (culmed vegetative or reproductive shoots)



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Other Common Jointed Grasses

Bromegrass

Reed Canarygrass

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Non jointed Grasses –Tall Fescue

Non-jointed grasses have a low to medium percentage of tillers that produce a seed heads in the spring relative to vegetative tillers and are non-jointed in aftermath growth

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Other non-jointed Grasses

Other non-jointing grasses with a medium number of tillers that head in the spring: **Orchardgrass**, Meadow Fescue, Meadow foxtail

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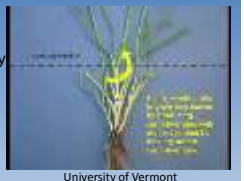
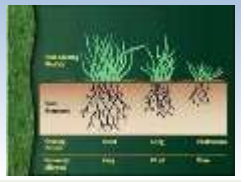
Cutting Height

Cutting height affects winter injury susceptibility

- Cutting too low weakens the plant. Reduces productivity, –reduces root mass
- Energy reserves increase in the crowns of plants during the latter part of the growing season, just prior to dormancy as buds develop for next year's tillers.
- If severe defoliation occurs near the end of the growing season, the production of crown tissue will decrease and cause next year's crop production to yield less. –snow catchment and insulation



University of Vermont



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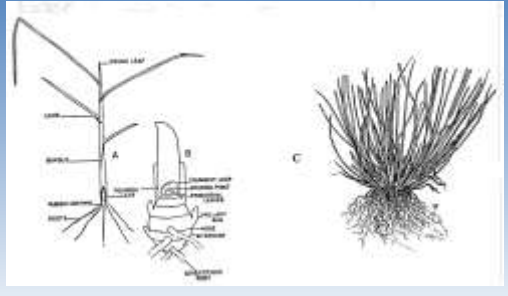

How Grass Grows – University of Oregon State publication

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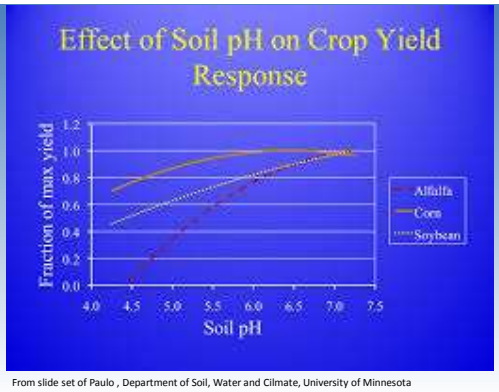

From slide set of Paulo , Department of Soil, Water and Cilmate, University of Minnesota

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Soil Fertility - Benefits of Liming

- Increased yield
- Increases nutrient availability (fertilizer efficiency)
- increased stand establishment and persistence
- Increased legume content

- more activity of nitrogen-fixing *Rhizobium* bacteria
- added calcium and magnesium
- improved soil structure and tilth
- increased availability of phosphorus and molybdenum
- decreased manganese and aluminum toxicity

Healthier plants withstand stress better!!

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Potassium

As a general rule 70 kgs of potash is removed with every dry matter tonne of legume forage harvested. A 3.5 tonnes per hectare yield could mean 250 kg of potash removed per year.

Effect of K Fertilizer on alfalfa Yield, P Content and Plant Protein

Rate of K_2O Kg/ha	Yield	Plant K Content (%)	Plant Protein Content (%)
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 location on three soils

Bulletin on Fertilizing alfalfa Soils Manitoba Government

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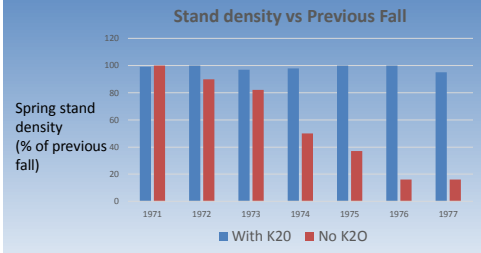
Potassium



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. The above graph shows the effect of potassium fertilization on preventing winterkill of alfalfa on a sandy loam soil over an eight-year period

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Phosphorous

Phosphorus is the most important nutrient to apply at seeding time. The use of phosphorus fertilizer increases seedling vigour. Applying 33 kilograms/hectare) (30 lb/acre) during seeding has been shown to increase seedling size of alfalfa by four times compared to no phosphorus application. Cool shorter season areas need phosphorous.

Effect of P Fertilizer on alfalfa Yield, P Content and Plant Protein

Rate of P_2O_5 Kg/ha	Yield	Plant P 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 location on three soils

Bulletin on Fertilizing alfalfa Soils Manitoba Government

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Influence of P & K on Total Annual Yield

Purdue researchers showed that an alfalfa stand fertilized with 50 to 150 pounds of P_2O_5 per acre per year and 200 to 400 pounds of K_2O per acre per year had higher yields than unfertilized stands. Providing adequate P and K fertilizer slowed yield reduction over time, resulting in progressively greater yield advantages due to P and K fertility as stands aged.

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Source OMAFRA Fact sheet "Sulphur on Alfalfa" Joel Bagg

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Alfalfa Tissue Analysis
2012 Farm Survey

Nutrient	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5
Phosphorous (0.30 - 0.39%)	-	0.50 %	0.39 %	0.42 %	0.39 %
Potassium (1.25 – 1.6%)	-	2.68 %	3.57 %	2.48 %	3.09 %
Sulphur (0.27 – 0.35%)	0.27 %	0.30 %	0.24 %	0.27 %	0.29 %
Boron (21 - 80 ppm)	-	30.66 ppm	33.25 ppm	32.18 ppm	32.50 ppm

Sulphur deficiencies can be confirmed with tissue tests. A soil test is generally not considered to be a reliable test for S. Plant samples were collected from 5 farms when the crop was in the bud to first flower stage. The top six inches from 30 to 40 alfalfa stems were collected from a field at each farm and submitted to the NSDA laboratory for tissue analysis.
If the S concentration is below 0.25 % S, then applications of 28 kg/ha of S is needed. If sample test are greater than 0.25% S then no economic response to sulphur is expected.

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Crop Removal Rates "S"

Crop	Yield /hectare	Sulphur kg/ha	Crop	Yield /hectare	Sulphur kg/ha
Grain Corn	375 bu	11.2	Wheat grain	200 bu	6.7
Corn Stover	10.2 tonnes	16.8	Wheat straw	6.8 tonnes	11.2
Soybeans	100 bu	4.5	Barley grain	150 bu	5
Canola	112 bu	16.8	Barley Straw	4.5 ton	6.7
Dry Beans	75 bu	5.6	Oats grain	200 bu	5.6
Alfalfa	11.3 tonnes	28.0	Oats Straw	4.5 tonnes	10.1
Red Clover	5.7 tonnes	7.8	Rye grain	112 bu	11.2
Timothy Hay	5.7 tonnes	5.6	Rye Straw	4.5 tonnes	4

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Sulphur

1999 – 2000 C. Lapierre & R. Simard, Agriculture and Agrifood Canada showed a 1.78 MT D.M./Ha yield advantage to applying sulphur to orchardgrass

In a four-year Virginia Tech study, calves in a continuous stocking system showed an 18% increase in average daily weight gain when fed fescue fertilized with ammonium sulfate, compared to calves fed with fescue that had been supplied with ammonium nitrate at similar N rates, but with no S. In fact, over a seven-month feeding period, the total weight gain advantage from the ammonium sulfate fertilized forage was 65 pounds per calf

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Fertilizer Recommendations

Field # 23 — **pH** 6.1 — **P_2O_5** 568 — **K_2O** 194
Year: 2019 — **Crop:** legume forage — **Size:** 7.75acres

Fertilizer :

15	10	24	@	200	lbs/acre	spring	BO.2 5%S
16	0	31	@	200	lbs/acre	after each cut	6%S AS
0	0	60	@	150	lbs/acre	after last cut	

Field # 18 — **pH** 6.2 — **P_2O_5** 339 — **K_2O** 182
Year: 2019 — **Crop:** grass forage — **Size:** 4.75acres

Fertilizer :

25	6	18	@	275	lbs/acre	spring	3% S AS
30	0	21	@	200	lbs/acre	after 1st cut	Agrotain

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Winter Injury in Alfalfa -Options

As management options are considered, remember that injured alfalfa stands can exhibit delayed regrowth, but may be capable of recovering. Be careful not to rush into alternative options if the stand can be maintained for acceptable production. If action is required, carefully consider the cost and expected benefit of remediation.

Supplemental forages such as annual ryegrass, and small grains can be inter-seeded into a thin stand or used to cover the "bad spots". If a large percentage of the stand has been damaged, termination and planting of silage corn may be more appropriate.

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Winter Injury in Alfalfa -Options

Make an Early Decision to Rotate

If an alfalfa field shows early signs of winterkill, such as mushy plant crowns and roots, growers could plan to rotate directly to corn without waiting and fretting over slow or sparse spring green-up. Making an early decision to rotate allows you to take advantage of the nitrogen savings in corn. Fields that had a good stand of alfalfa going into winter should provide the entire nitrogen requirement for a following corn crop if rotated this spring

A. No injury. Roots are solid white internally

B. Moderate injury. Roots are solid and white but brown damaged areas occur

C. Severe injury. Roots white on outside. Brown discoloration carries down in center of the root.

D. Dead plants. Roots are discolored, mushy and partly rotted

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Winterkill in Alfalfa

•**Red clover** (Average seeding rate of 6-10 pounds per acre) can help prolong the life of alfalfa by an average of two years. This is a great option for producers that harvest their forage for haylage.

•**Small grains and annual cool season grasses** (Examples: Oats, wheat, rye, or triticale, annual or Italian ryegrass) can provide high quality forage fast, and prolong the stand life for one year.

•**Interseed perennial grasses** such as orchardgrass (5-10 pounds per acre), or tall fescue (4 - 8 pounds per acre) could enhance stands for two or more years depending on establishment.

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Corn Silage

Corn silage produces more tonnes per hectare than any other annual forage. Following a full stand of alfalfa no extra N fertilizer is required beyond what goes down in the planter. Often the limiting factor to growing this crop is the specialized equipment needed to plant and harvest the crop

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Sorghum-Sudan Grass Hybrids

Sorghum-Sudan grass hybrids offer a solution to producing forage dry matter when an emergency occurs. Sorghum-Sudan grasses yield slightly lower than corn when harvested for silage, but they have the advantage that they can be cut 2-3 times during the season and can also be stored as either chopped silage or wrapped bale silage, green chopped or pastured. As silage crops, they rank below corn in feeding value, unless they have the brown-midrib trait.

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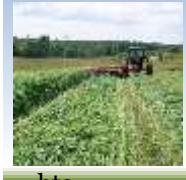
Sorghum-Sudan

- ❑ Suppresses weeds
- ❑ Suppresses nematodes
- ❑ Builds soil organic matter
- ❑ Reduces soil compaction



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