Sod Seeding

seeding forages into existing stands using minimal tillage

SEEDING FORAGES INTO EXISTING STANDS USING MINIMAL TILLAGE

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Cover: The calf is on a Kentucky bluegrass pasture (Sekirk Osborne clay soil) near Selkirk, Manitoba. This pasture had never been broken and was first frost seeded 20 years ago in spring using an ATV with a broadcaster and a chain harrow. It has been re-seed approximately every two years since then. The forages applied were alfalfa, orchard grass and meadow brome. Some phosphate fertilizer was also mixed in with the seed.

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INTRODUCTION

In recent years, many Canadian farmers have found that grazing on productive pastures can be very profitable. However, many pastures are far from productive as the amount and quality of forage does not meet the needs of the growing livestock. Considerable research has been conducted in various regions of Canada and the United States to develop methods to rejuvenate pastures (Bartholomew 2005, Seguin 1998, Waddington 2004).

1. DETERMINING THE CONDITION OF PASTURE/ HAYLAND

Unproductive pastures are usually a result of the type of forage species present. In most low-producing pastures, the species that exist are the “survivors”. These are the species that have adapted to long periods of overgrazing, lack of rest, and poor soil due in part to poor grazing management practices. Low-producing grasses, brush or weeds are often the primary species on “tired pastures”. Legumes in particular are lost in pasture by overgrazing, disease, poor fertility, drought or excess moisture or a combination of these factors. The following guidelines can be used to determine the condition of pastures and hayland.

Determining the Condition of Pasture/hayland

	Excellent	Good	Fair	Poor
Yield as a % of potential yield for your area	75-100%	60-75%	50-60%	Less than 50%
Production from desirable species	95%	75-95%	50-75%	Less than 50%
Production from undesirable species/weeds	5%	5-25%	25-50%	More than 50%
Suggested management	Maintain current management.	Maintain current management.	Change management. May be able to rejuvenate by fertilizing, mowing, herbicide use, rest periods. Consider adding new species.	Change management. Add new species and improve grazing management.

Adapted from SAFRR (2002b) and G. Ehlert, Alberta Agriculture (1990).

Current management practices should be maintained for stands that are in good or excellent condition. If a stand is in fair condition changes in management and the adoption of rejuvenation practices should be considered rather than re-seeding. Management changes include grazing practices, long rest periods, herbicide use, mowing and fertilization. These methods can often return stands to good condition in two to three years. Research in Alberta has shown that mechanical methods of rejuvenation such as aeration or spiking have little benefit unless they are used in conjunction with fertilization, suggesting that nitrogen fertility is the limiting factor in many old forage stands (Malhi and McCartney 2004). If a stand is in poor condition, more expensive methods involving re-seeding should be considered, and it may take longer to return the stand to good condition (SAFRR 2002a). If you are planning management changes that will reduce forage production in the short-term, apply them to a small number of acres to minimize the overall loss of forage production.

2. METHODS OF ADDING NEW FORAGE SPECIES

Adding new forage species to a pasture can improve its productivity. In particular, adding a legume such as alfalfa can increase the yield and nutritional quality of the forage and add nitrogen to the soil.

There are many ways to add new species to a forage stand. Terminating the existing pasture and seeding a new forage stand is the most effective method of changing the forage species. However, some soils or economic conditions make this an unprofitable option. Also, if you have not changed your grazing management, such as practicing a rest/recovery system, you will be back to the original low productive pastures in short order. An alternative to terminating and re-seeding is to seed new species into the established stand.

There are **three basic techniques** to add new forage species:

a. Renovation

The traditional approach has been to terminate the existing stand using a non-selective herbicide such as glyphosate, followed by tillage to create a firm, smooth, weed-free seedbed. The prepared area is then reseeded with the desired species. This method requires time – generally two years – although an annual crop such as oats or barley may be produced during the first year. A number of tillage passes may be required, resulting in high fuel consumption. In addition, it is generally not suitable for steep inclines, erodible soils, or stony ground.

Growing an annual grain crop for a couple of years may be beneficial when seedbed conditions are poor, or there are disease, weed, or autotoxicity problems (Hutton et al. 2005). Cultivation and herbicide treatments associated with growing the grain crop can also reduce the regrowth from dormant seed from the previous pasture stand. However, it is important to consider that if there is good soil moisture in a given spring, it may be best to take advantage of it and seed perennial forage species rather than growing an annual crop. Waiting until a later year may result in a dry spring and poorer conditions for perennial forage establishment (SRC 1996b).

Growing an annual crop after no-till termination of a forage stand may require multiple herbicide applications to control weeds and existing forage grasses prior to establishing a new forage stand. A Saskatchewan study investigated growing an annual crop after spraying bluegrass, smooth bromegrass, or crested wheatgrass pastures with glyphosate prior to sod seeding a new forage stand. One method was to sod seed an alfalfa/grass mix immediately after applying 3 L/ac (356 g ai/L) spring glyphosate. The second method was to seed an annual crop after applying 3 L/ac (356 g ai/L) spring glyphosate and then sod seed the alfalfa/grass mix the next spring, without any other herbicide application or tillage operation. Sod seeding without an intervening annual crop was more successful, because the annual crop did not compete well enough with perennial weeds/grasses that escaped control with glyphosate (SRC 1996b).

The Agriculture and Agri-Food Canada Brandon Research Centre in Brandon, MB has successfully used a variation of the practice of tilling the sod and growing an annual grain crop for one year before reseeding a forage stand. The existing forage stand is grazed as usual and then sprayed out late in the season. Only one or two tillage passes are then used before freeze-up. The following spring an annual cereal is direct-seeded and then swath-grazed in fall before the ground is frozen. The high-density stocking and hoof action of the swath-grazing completes the breakdown of the sod material, producing an ideal seedbed for direct-seeding a new forage stand the following spring. This method ensures ongoing productivity and uses a minimal number of tillage passes, resulting in a significant reduction in the cost of breaking and re-seeding a forage stand (C. Robins, AAFC Brandon, personal communication).

b. Broadcast Seeding

A second alternative is to broadcast seed directly into the existing stand, with some disturbance to increase the contact between seed and soil so germination can occur. Disturbance can be in the form of natural processes such as frost heaving, allowing grazing animals to trample the seedbed, or using equipment to disturb the seedbed mechanically (harrowing, spiking, or drag beam). However, vigorous harrowing or spiking can reduce forage production in the year of seeding.

Broadcast seeding is risky because establishment is very dependent on the weather, especially moisture conditions. Moisture and humidity levels change quickly on the soil surface, creating poor conditions for germination. The roots of broadcast seedlings can also have difficulty penetrating the soil surface. It works best if stands are thin and have been suppressed to reduce competition. The more bare ground there is, the more successful this method tends to be. Broadcast seeding without suppressing the existing stand and without disturbance to improve seed-soil contact is less likely to be successful. For example, a study in North Dakota investigated broadcast seeding alfalfa into native pasture without any method of sod suppression and no disturbance following broadcasting. Nine different alfalfa varieties were tested, seeded at a rate of 1 lb pure live seed/ac. Establishment of alfalfa failed in all cases (Manske 2005a).

Because of the risks involved, broadcast seeding is usually done with less expensive species such as alfalfa and clovers. Some producers in Alberta have reported more success with small-seeded species such as yellow-flowered alfalfa or alsike clover (H. Yoder, personal communication). Small seeded grasses can also be successful. Broadcast seeding should be done as early in spring as possible to ensure good moisture. Dormant seeding in fall is also an option (SAFRR 2002a) and will be discussed in detail later in this manual.

Traditional spinner spreaders can be used to apply forage seed, but due to differences in seed weight and size, it can be difficult to spread seed mixtures accurately with this equipment. Fluffier seeds such as smooth bromegrass are not flung as far as heavier seeds such as alfalfa or clover, leading to an uneven distribution of grasses and legumes. For this reason more producers are using a dribble type of boom spreader with either air or mechanical distribution systems. Floaters, Tera-Gators and Valmars are included in these types of systems. Seed distribution is generally very good and may permit the application of fertilizer at the same time.

Mixing fertilizer or inert material such as cracked grain or horticultural vermiculite with the forage seed may improve seed flow and even out seed application, particularly with bromegrasses (Hutton et al. 2005). However, if you are using fertilizer in the seed mix, you must seed immediately after blending because the salt content of most fertilizers can damage seeds and reduce germination. Don't mix more than you can seed in one day (MAFRI 2006a). Using coated seed can also improve seed flow and improve accuracy (H. Yoder, personal communication). However, some coated seed can contain a large amount of coated inert material, resulting in very poor stand establishment (M. Schellenberg, personal communication).

c. Direct-seeding (Sod Seeding)

The third strategy is to use low-disturbance equipment such as a zero-till drill or a sod seeder to seed directly into the existing stand. This is commonly referred to as sod seeding. In the past, sod seeding often failed because seeding equipment did not allow for accurate seed placement, and there were limited options to control competition from the existing vegetation prior to seeding. However, recent developments in commercially available seeding equipment and non-selective herbicide technology have greatly improved the success of this technique. Research has shown that sod seeding requires approximately half the energy input required by conventional seeding methods (PAMI & AFMRC 1993).

Figure 1. Broadcast Seeding with ATV

Figure 2. Seeding wtih double-disc sod seeder

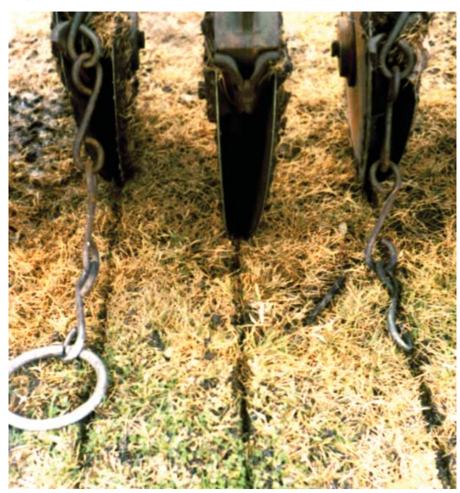


Figure 3. Spring sod seeding wth drill

Advantages of Reduced-tillage Seeding

- Less land production losses compared to breaking and reseeding.
- Pasture land is fragile and subject to erosion. Less tillage reduces erosion and organic matter loss.
- Access to rough terrain is easier than with traditional seeding methods.
- Cheaper than breaking and reseeding – uses less fuel, labour and wear and tear on equipment.
- Reduced tillage conserves moisture, especially near the soil surface. Moisture in the soil surface layer is essential for germination and emergence of small-seeded forage crops.
- Residue on the soil surface protects seedlings from wind erosion and dessication.
- Stores carbon in the soil, reducing the release of carbon dioxide, a greenhouse gas.
- Leaves wildlife habitat intact.

There are a number of challenges that must be addressed in order to successfully seed forages into existing stands with minimal tillage. The existing vegetation can cause severe competition with new forage seedlings if not suppressed prior to seeding. For example, research in southwest Saskatchewan found that a minimum 20-inch suppression zone, with the legume seeded at the centre, was required to successfully sod seed alfalfa into crested wheatgrass (Schellenberg et al. 1994). Using the appropriate species, seeding equipment, seeding date, and fertilizer will help improve establishment.

3. SPECIES SELECTION

There are many species of legumes, as well as tame and native grasses, that are applicable to various ecosystems in Canada. Tolerance to shading and low moisture is important when selecting a species and a variety for sod seeding. The existing vegetation can shade young seedlings and cause significant competition for moisture. Species with quick emergence and good seedling vigour will compete well with existing vegetation. Consult the Manitoba Agriculture, Food and Rural Initiatives Forage Adaptation Guide (MAFRI 2007) or the Forage Seed Guide specific to your province for your species selections.

a. Legumes

Since the purpose of adding a new species to a forage stand is to improve the quality and yield, a legume is recommended. The recommended percentage of legumes in pasture is 30-50%. Pasture with a legume content of greater than 30% should be managed carefully to reduce the incidence of bloat. Cicer milk-vetch, sainfoin and birdsfoot trefoil are non-bloating; however, experience has shown that these forages are not as good as alfalfa in terms of ease of establishment, yield, re-growth and persistence.

Benefits of Adding Legumes to a Forage Stand

- Legumes increase the total yield of forage per acre.
- Legumes improve forage quality over grass alone with an increase in available crude protein.
- Legumes fix nitrogen. Once legumes are established, the existing grasses thicken and increase in vigour as a result of the nitrogen fixed by the legume.
- Legumes stabilize forage yield throughout the year due to seasonal variation in yield of grasses and legumes.

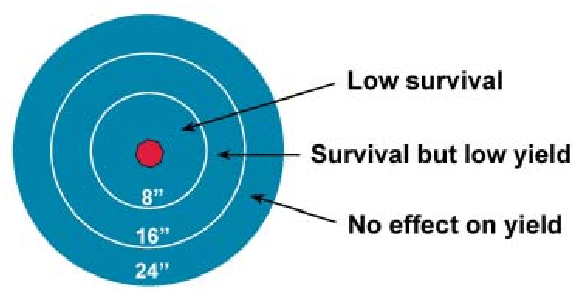
i. Alfalfa

Alfalfa is the easiest legume to establish, and can be used for both hay and pasture. The seedlings are vigorous, the plant grows rapidly, and the crop is adaptable to a wide range of soil and moisture conditions, except where moisture is excessive. A study at Tolstoi, MB successfully seeded alfalfa (2.4 lb/ac) as part of a legume/grass mixture using a variety of minimal-tillage seeding strategies into a pasture dominated by bluegrass, quackgrass, and broadleaf weeds. The pasture was first suppressed with 2.25 L/ac (356 g ai/L) fall-applied glyphosate (McCartney et al. 2007). Alfalfa was also successfully seeded near Ituna, SK with a zero-till rangeland drill into bluegrass pastures suppressed by heavy grazing and 2.8 L/ac (356 g ai/L) glyphosate (SRC 1994).

Autotoxicity - Alfalfa plants produce toxins (called medicarpins) that reduce the germination and growth of new alfalfa seedlings, a phenomenon known as autotoxicity. You should not attempt to seed alfalfa back into an alfalfa field within 12 months of killing the old alfalfa. It is also **not** recommended that alfalfa be seeded to thicken an established alfalfa stand, as this is rarely successful. New seedlings often germinate, look acceptable initially, and then die out over the summer. Studies have shown that yields are reduced when alfalfa is seeded after alfalfa, regardless of the waiting period. This yield reduction appears to persist every year for the life of the stand. Stands affected by autotoxicity appear to regrow slower after each cutting. Yield reductions from autotoxicity can be difficult to recognize and are often attributed to other causes. For maximum yield, if the alfalfa is two or more years old, an intervening year of an alternate crop is required before reseeding to alfalfa. If the old stand has little or few alfalfa plants, caution is still required, but the risk of autotoxicity decreases.

Figure 4. Alfalfa Field

Figure 5. Zone of Influence



Zone of influence of an old alfalfa plant on new alfalfa seedlings.

Source: John Jennings, U of MO

When planted within 8 inches of an old alfalfa plant, new seedlings rarely survive, and if they do, yields are only 30% of maximum. At 16-24 inches away from an old plant, new plants achieve maximum growth and yield. Seeding into an alfalfa stand with a density of 0.2 plants/ft^2 or less would result in success (this is well below an optimum stand). Having good knowledge of the alfalfa plant stand count in the old stand is important. However, the density of alfalfa is often quite patchy, making it difficult to assess the stand. Be aware that autotoxicity can be an issue in areas where the density of alfalfa is higher.

Factors Affecting the Level of Alfalfa Autotoxicity in the Soil
Age of stand: Damage due to autotoxicity increases with the age of the previous stand.There is no autotoxicity effect in a stand less than one year old. Seeding failures or new seedings that were winterkilled can be reseeded without an autotoxicity effect.
Soil type: Autotoxicity in the first year after seeding is most severe in sandy soils.However, the toxin is water-soluble and can leach out of the rooting zone with sufficient precipitation. Autotoxicity lasts longer on clay soils, due to poor drainage. It does not last for as many years in well-drained, sandy soils.
Plant density: Higher stand densities have higher concentrations of the toxin in the soil.
Residue: Fields with more top growth residue will have higher autotoxicity. Remove all residues during harvest if you plan on reseeding.
Tillage: Tilling the stand as soon as possible following harvest can reduce autotoxicity. In minimum or no-till circumstances, autotoxicity can be a greater problem.

Adapted from MAFRI (2006a)

ii. Red clover

In general, red clover is the most successful legume species used for sod seeding in North America (Seguin 1998). In a study near Tolstoi, Manitoba, four different methods of seeding forages into an ungrazed bluegrass/quackgrass dominated site were tested. Red clover seeded at 2.4 lb/ac was the most aggressive species seeded. The next most aggressive species was alfalfa (also seeded at 2.4 lb/ac). The least aggressive species in this study were birdsfoot trefoil, timothy, tall fescue, and meadow bromegrass (McCartney et al. 2007). A study comparing red clover, white clover and kura clover sod seeded in Minnesota and Quebec also found that red clover was the most aggressive species (Laberge et al. 2005a).

iii. Birdsfoot trefoil

Birdsfoot trefoil was successfully sod seeded at a rate of 8 lb/ac into two Saskatchewan smooth bromegrass/alfalfa pastures after a 2 L/ac (356 g ai/L) spring glyphosate application. In this experiment, the moisture conditions were ideal (SRC 1996a). However, in a trial in northeastern Saskatchewan, establishment of birdsfoot trefoil was much less successful compared to alfalfa, red clover, cicer milkvetch, and sweet clover when seeded into pastures dominated by native grasses or northern wheatgrass. In that study, birdsfoot trefoil was broadcast at 1.6 lb/ac and followed by heavy chain-link harrows, or followed by an AerWay tillage system that cuts into and opens up the sod plus heavy chain-link harrows. There was no herbicide or other sod-suppression method used (McCartney et al. 2007).

iv. Cicer milkvetch

Cicer milkvetch was successfully sod seeded into two Saskatchewan smooth bromegrass/ alfalfa pastures after a 2 L/ac (356 g ai/L) spring glyphosate application under ideal moisture conditions. It was seeded with a Truax sod seeding drill and the seeding rate for both species was 11.6 lb/ac (SRC 1996a). In another Saskatchewan study, it was also successfully seeded into a pasture consisting of Kentucky bluegrass, bromegrass, and creeping red fescue (Malik and Waddington 1990). In that experiment, cicer milkvetch was seeded into strips sprayed with fall-applied glyphosate (2.5 L/ac (356 g ai/L)). It was seeded in either late fall (dormant seeding) or early spring, but the late fall dormant seeding resulted in better establishment than spring seeding. In an Alberta study, scarified cicer milkvetch was successfully established in bromegrass pastures that had been heavily grazed prior to seeding, but it took three years to establish a satisfactory stand (McCartney et al. 2007). In that study, cicer milkvetch was broadcast at 5.4 lb/ac and incorporated with two passes of an AerWay tillage system.

v. Crownvetch

Crownvetch generally fails to establish when sod seeded (Seguin 1998). It was successfully established into switchgrass in an Iowa study; however, establishment was not as good as other legume species tested in the study. In that study, crownvetch was seeded with a double disc seeder at a seeding rate of approximately 7 lb/ac, and the switchgrass was suppressed by mowing in the fall and spring prior to seeding (Blanchet et al. 1995).

vi. Kura clover

Kura clover was successfully sod seeded in Minnesota and Quebec using two different no-till drills. The kura clover was seeded into smooth bromegrass and Kentucky bluegrass dominated sites following a spring glyphosate application. However, establishment of kura clover was lower than both red clover and white clover (Laberge et al. 2005a).

vii. Purple prairie clover

Purple prairie clover was successfully sod seeded into two Saskatchewan smooth bromegrass/alfalfa pastures after a 2 L/ac (356 g ai/L) spring glyphosate application, when moisture conditions were ideal. The seeding rate was 11.6 lb/ac (SRC 1996a).

viii. Sweet clover

Sweet clover is a good establisher and is drought and salt tolerant, but it is not highly recommended as it is biennial, not perennial. Both white and yellow-flowered sweet clover have been successfully established with sod seeding (Seguin 1998). It was successfully established in several pastures in northeastern Saskatchewan when broadcast (3.2 lb/ac) followed by either heavy chain-link harrows, or by an AerWay tillage system. Herbicide or other sod suppression methods were not used (McCartney et al. 2007).

ix. White clover

White clover was successfully established in a timothy and Kentucky bluegrass pasture in Prince Edward Island where the sod was suppressed by a banded application of paraquat. The white clover was seeded at 4.5 lb/ac (Kunelius and Campbell 1984). It was also established by sod seeding into smooth bromegrass and Kentucky bluegrass in Minnesota and Quebec. In that study, two different no-till drills were used to seed following a spring glyphosate application. Establishment of white clover was better than kura clover but less successful than red clover (Laberge et al. 2005a). However, white clover thrives under moist conditions, and results may be different in regions with drier soil conditions than the locations where these studies were conducted.

b. Tame Grasses

Tame grasses are difficult to establish when native grasses or bluegrass are already present in the sward (MAFRI 2006b).

i. Timothy, meadow bromegrass, and tall fescue

Research at Tolstoi, Manitoba found that when timothy (1.6 lb/ac), meadow bromegrass (3.2 lb/ac), and tall fescue (3.2 lb/ac) were seeded into a bluegrass/quackgrass pasture using four different minimal tillage seeding methods, the only grass to show any success was timothy. The pasture had been suppressed with a fall-applied treatment of 2.25 L/ac (356 g ai/L) glyphosate (McCartney et al. 2007). However, meadow bromegrass was successfully seeded into pastures dominated by bluegrass, smooth bromegrass, or crested wheatgrass in Saskatchewan. A Truax grass drill was used, and glyphosate was spring applied at 3 L/ac (356 g ai/L) before seeding (SRC 1996b).

ii. Intermediate wheatgrass

Intermediate wheatgrass was successfully sod seeded into bluegrass, smooth bromegrass, and crested wheatgrass pastures in a mixture with other grasses and alfalfa in Saskatchewan using a Truax grass drill (SRC 1996b). Glyphosate was spring applied at 3 L/ac (356 g ai/L) before seeding.

iii. Tall wheatgrass

A study in Manitoba found that tall wheatgrass was easier to establish by sod seeding into timothy or bromegrass/bluegrass pastures than green needlegrass or switchgrass (Gobin 1995). In that study, glyphosate was spring applied at 2 L/ac (356 g ai/L) one to three days prior to seeding and packed with a lawn packer twice after seeding. A Connor Shea Coil Tyne Coulter sod seeding drill was used.

iv. Orchardgrass

Some Manitoba producers have successfully sod seeded this species. It is a competitive, short lived species with marginal winter hardiness (G. Friesen, MAFRI, personal communication).

Figure 6. Orchard grass frost seeded into a pasture near Selkirk, MB.

c. Native Grasses

i. Blue grama grass

Blue grama grass was successfully seeded into a 50-year old crested wheatgrass stand in Saskatchewan when a high seeding rate was used (17.5 and 21 lb pure live seed/ac). The crested wheatgrass was suppressed with glyphosate 1.2 L/ac (356 g ai/L) in spring (Bakker et al. 1997). The blue grama was either broadcast after roto-tilling or direct-seeded with a double disc drill.

ii. Needle-and-thread grass and Junegrass

Neither were successfully established in 50-year old crested wheatgrass stands in Saskatchewan. This may have been due to seed dormancy in these species. A double-disc drill was used to seed after a 1.2 L/ac (356 g ai/L) glyphosate spring application. The needle-and threadgrass was seeded at 5 lb pure live seed/ac and Junegrass was seeded at 4 lb pure live seed/ac (Bakker et al. 1997).

iii. Green needlegrass, slender wheatgrass, western wheatgrass, northern wheatgrass, and switchgrass

These species were successfully sod seeded in Saskatchewan into bluegrass, smooth bromegrass, and crested wheatgrass pastures using a Truax double-disc grass drill. Pastures were suppressed using 3 L/ac (356 g ai/L) glyphosate (SRC 1996b). A study in Manitoba found that northern wheatgrass was more easily established by sod seeding than switchgrass and green needlegrass. The grasses in this study were seeded into timothy or bromegrass/bluegrass pastures with a Connor Shea Coil Tyne Coulter sod seeding drill and then packed with a drum roller twice after seeding. Glyphosate (2 L/ac (356 g ai/L)) was applied in spring prior to seeding (Gobin 1995).

d. Legume and Grass Mixtures

Sod seeding grass-legume mixtures may be more competitive against weeds than legumes alone. A study in Saskatchewan found that fewer weeds were present when a grass was sod seeded along with a legume rather than a legume alone (SRC 1996a). However, it can be difficult to broadcast mixtures of legume and grass seed accurately with a spinner spreader, due to differences in seed weight and size among legumes and grasses. This can lead to an uneven distribution of forage plants within the stand. Alfalfa emerges more quickly than most grass seedlings and can out-compete them, so seed ratios are critical (PAMI & AFMRC 1993). Examples of seed mixtures for seeding new stands of pasture and hay land are given in the following tables. *These rates should be increased when used for sod seeding.*

Pasture and Hay Grass/legume Mix Seeding Rates

	Pasture mix lb/ac (seeds/ft^2)	Hay mix lb/ac (seeds/ft^2)
Alfalfa	1 (4.5)	6-8 (30-40)
Trefoil	1 (4.5)	0 (0)
Meadow brome	5 (9.1)	4 (7.3)
Tall fescue	3 (15.6)	0 (0)
Timothy	2 (56.6)	2 (56.2)
Total	**12 (90)**	**12-14 (94-104)**

Source: MAFRI (2006a)

Recommended Seed Ratios for Black and Grey Wooded Soils

Species mix	Pasture mix (lb/ac)	Hay mix (lb/ac)
Smooth bromegrass + alfalfa	7+1	4+5
Crested wheatgrass + alfalfa	6+1	6+3
Intermediate wheatgrass + alfalfa	11+1	11+3
Meadow bromegrass + alfalfa	10+1	10+2

Source: SAFRR (2007)

4. FERTILIZATION

All forage species need adequate fertility to establish successfully. Soil testing your field for nutrient requirements before seeding is a very valuable management tool. It is also important to identify any limitations such as acidity or salinity so that appropriate species can be selected. All nutrients should be applied according to recommended soil test rates. Directions for soil sampling and fertilizer recommendations for alfalfa and other forages are found in the Manitoba Agriculture, Food and Rural Initiatives' Soil Fertility Guide (MAFRI 2006g).

a. Nitrogen

Do not apply nitrogen (N) fertilizer when seeding legumes. Nitrogen fertilization is not necessary for legumes as they produce their own, provided they are properly inoculated. Applying N will instead stimulate established grasses and decrease the establishment of legume seedlings. In mixed legume/grass stands, N fertilization reduces nodulation of the legumes thereby decreasing their ability to fix atmospheric N. n Grasses are able to use high levels of applied N fertilizer more effectively than the legumes and thus become more competitive against the legume. The result can be a reduction of the legume component of the stand (SSCA 2005).

If forage grasses are being seeded into grass-dominated stands without seeding a legume, N fertilization is important. Perennial grasses need high levels of N and respond well to fertilization, especially in regions with higher moisture (Malhi and McCartney 2004).

b. Phosphorus

Phosphorus (P) tends to improve the establishment of forage seedlings. It is particularly helpful for root development and improving seedling vigour. Phosphorus is the most important nutrient to apply at seeding time for alfalfa. Applying 30 lb/ac during seeding has been shown to increase alfalfa seedling size by four times compared to no phosphorus application (MAFRI 2006d). The residual effect of one application of phosphorus can last for five to ten years (Malhi and McCartney 2004).

Manitoba research has shown the value of applying P when sod seeding legumes. One study (Tolstoi, MB) used 40 lb/ac P_2O_5 prior to sod seeding alfalfa, timothy, birdsfoot trefoil, and red clover. Phosphorus application increased the percentage of legumes and dry matter of alfalfa compared to no P application (McCartney et al. 2007). Another Manitoba study of sod seeded alfalfa (at Gladstone and Portage, MB), found that applying P_2O_5 improved plant emergence and vigour, and increased dry matter production significantly compared to unfertilized alfalfa. Applying 36 lb/ac P_2O_5 improved plant vigor but did not affect emergence or dry matter production significantly compared to 27 lb/ac (MAFRI 2006c).

Alfalfa responds to P best when it is banded one inch directly below the seed. Good response is also obtained with placement one inch below and one inch 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 (MAFRI 2006d). However, it is difficult to band fertilizer accurately in the rough, uneven conditions of most hay fields and pastures.

Seed-placed P fertilizer containing ammonium (e.g. mono ammonium phosphate - MAP) can be toxic to alfalfa seedlings. The current recommendation is that no phosphate should be placed with the seed. Safer placement options are side-banding, pre-plant banding or pre-plant broadcasting. The risk of toxicity with seed-placed P is higher when there is a higher concentration of fertilizer in the row. This occurs when the width of spread of seed and fertilizer is low (in a narrow band), and when row spacing is wider. The narrower the band of seed plus fertilizer in each row, the more concentrated the fertilizer is. Similarly, the further apart the rows are, the more concentrated the fertilizer in each row. The risk of toxicity is also higher in dry and sandy soils. Seed placed phosphate may be acceptable when using a seeder with a lower concentration of seed and fertilizer, under favourable moisture conditions (which are more likely in early spring). A study at Carman, MB showed a severe reduction in alfalfa stands when 30 lb P_2O_5/ac (MAP) was applied with the seed in a row with a ½ inch wide furrow. At other Manitoba sites with higher soil moisture and a one-inch seed spread, alfalfa tolerated 30 lb/ac P_2O_5/ac (MAFRI 2002).

Some forage seed mixtures may require the addition of fertilizer to ensure a uniform seed flow through the metering system. If you are mixing fertilizer with seed to be broadcast, you must seed immediately after blending because the salt content of most fertilizers can damage seeds and inoculant. Fertilizers with a low nitrogen content (e.g. MAP) should be used for tank mixing with forage seed. Do not mix more than you can seed in a day (MAFRI 2006a, Hutton et al. 2005). Additional information on agitation systems for seeding forages can be found in forage seeding studies at PAMI Humbolt SK (1997).

c. Potassium

Most agricultural soils in western Canada contain enough potassium (K), but organic and coarse-textured soils are more likely to be K deficient. Alfalfa in particular has high K requirements. If soil test levels are low, KCl fertilization of alfalfa can stimulate nitrogen fixation, improve yield and forage quality, and reduce winterkill (Malhi and McCartney 2004; MAFRI 2006d).

d. Sulphur

Soils on which sulphur (S) deficiency is most likely include well-drained sandy soils and the grey wooded soils. Grey wooded soils are found at the higher elevations in Manitoba such as the Turtle, Duck, Riding, and Porcupine mountains. Again, alfalfa has relatively high S requirements, as it is important in the production of protein by legume crops. Research has shown a higher response to S by alfalfa compared to grasses (Malhi and McCartney 2004, MAFRI 2006d). Sulphur fertilizer recommendations are based on sulphur being applied in the sulphate form since it is the only form readily available to plants. Elemental S is not available to plants until it is converted to sulphate in the soil, a process that can take time. Therefore, products containing elemental S are not recommended for use where the crop requires S in the year of application (MAFRI 2006d).

e. Micronutrients

Deficiencies of micronutrients are rare in perennial forages in western Canada, as most agricultural soils in western Canada have adequate levels. If a micronutrient deficiency is suspected, it should be confirmed either through a tissue analysis of the growing plant and/or observation of visual deficiency symptoms (MAFRI 2006d).

5. INOCULATING LEGUMES

Legumes require inoculation with rhizobia bacteria to properly fix atmospheric nitrogen. All legumes should be inoculated with rhizobia, even if the legume has previously been grown in the same location. Nodules developed from pre-existing rhizobia in the soil fix less nitrogen than freshly applied inoculant (MAFRI 2006e).

Be sure that the inoculant has not expired and is specific for the crop to be sown (e.g. red clover inoculant will not work on alfalfa). If the inoculant requires a sticking agent, use only the recommended commercial sticker. Seed treated on the farm should be seeded within 24 hours. If seeding is delayed, remove the inoculated seed from the seeder and store it in a cool, dark place (Hutton et al. 2005).

Pre-inoculated seed is coated with rhizobia by the seed retailer and can be seeded directly, but its effectiveness depends on proper application and storage (MAFRI 2006e). Pre-inoculation of alfalfa seed by seed retailers has been quite successful, and ensures 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, but ensure that pre-inoculated seed is not expired (MAFRI 2006d). Store inoculant or pre-inoculated seed in a cool, dark place until ready to seed.

Contact with fertilizer can harm inoculant. If fertilizer is mixed with inoculated seed, increase the inoculant rate to compensate.

6. SUPPRESSING THE EXISTING VEGETATION

Reducing competition from the existing stand is very important. Even in a very poor stand there is significant competition from already established plants. Suppression of existing vegetation will allow the new seedlings to access more sunlight, moisture, and nutrients. This is especially critical on drier sites, where there is increased competition for moisture. Research has shown that adequate moisture availability is the most important factor affecting many sod seeded species, including alfalfa and native grasses (Hart et al. 1985, Bowes and Zentner 1992).

Competition can be suppressed by overgrazing in the previous season, close mowing, chemical application, or some combination of these management techniques. A study in Minnesota tested 4 different methods of sod seeding legumes into existing pastures. Regardless of the seeding method, when no herbicide or other suppression method was applied, sod seeded legumes represented less than 3% of the stand. When glyphosate was applied at 0.7 L/ac (356 g ai/L) prior to seeding, sod seeded legumes represented almost one third of the stand (Cuomo et al. 2001). Similarly, a sod seeding study in east-central Saskatchewan found that alfalfa establishment was significantly higher when the existing bluegrass sod was suppressed by either glyphosate or rotovation (Bowes and Zentner 1992).

a. Competitiveness of the Existing Vegetation

The competitiveness of the species in the existing stand should be considered when selecting a method of suppression. Competitiveness is particularly important to consider if physical methods (such as overgrazing) are used to suppress the existing vegetation rather than herbicides, as physical methods are generally not as effective as herbicides. For example, one study found that the presence of competitive grasses such as orchardgrass and ryegrasses reduced sod seeded legume yields to a greater degree if physical methods of suppression were used than if herbicides were used (Seguin 1998).

In general, sod-forming grasses tend to be more competitive than bunch grasses. Sod-forming grasses include Kentucky bluegrass, creeping red fescue, intermediate wheatgrass, creeping foxtail, pubescent wheatgrass, northern wheatgrass, reed canarygrass, western wheatgrass, big bluestem, and quackgrass. Smooth bromegrass (sod-forming) is more aggressive than meadow bromegrass (bunch grass). Orchardgrass and crested wheatgrass also tend to be quite competitive even though they are bunch grasses.

Any grass that tolerates frequent defoliation with good regrowth will be very competitive and more difficult to suppress with non-herbicide methods. Species that grow vigorously in early spring will be competitive with spring-seeded forages. Kentucky bluegrass is particularly competitive. Less competitive grasses include timothy, tall wheatgrass, meadow fescue, and meadow bromegrass. Consult the Manitoba Forage Adaptation Guide for further information on competitiveness of different forage species (MAFRI 2007)

Methods for Suppressing the Existing Vegetation

HERBICIDE APPLICATION	
Pros	**Cons**
• Very effective at suppressing most stands, even competitive grasses.	• Dependent on weather and equipment availability.
	• High rates can suppress the stand too much, resulting in weed invasion, excessively high densities of bloat-causing species, or reduction in total forage production until sod-seeded species are mature.
	• Cost.
PHYSICAL (NON-HERBICIDE) METHODS	
Pros	**Cons**
• Cost of using grazing to suppress stand is minimal if fencing exists already.	• A single method or treatment generally does not suppress sod as effectively as herbicide. Often requires multiple treatments, or combination of different methods.
• Less likely to reduce total forage production compared to herbicide used.	• Intensive grazing requires greater management.

b. Suppression Without Herbicides

There are some advantages to using non-herbicide methods for suppressing the existing stand. Problems of timing the herbicide application are avoided. Also, when high rates of herbicide are used, the existing stand can be suppressed so severely that weed encroachment can be a problem. This does not usually happen when non-herbicide methods to suppress the stand are used (Seguin et al. 2001).

Physical suppression such as mowing or grazing is not always as successful as using herbicides to suppress the existing stand. Simply keeping the grass “short” may not be adequate if a very vigorous root system still exists or if the species are very competitive or tolerant to aggressive grazing or mowing (e.g. Kentucky bluegrass). Suppression must weaken the grass root system in order to reduce root vigor and competition for water the following spring. Severe physical suppression methods or multiple treatments may be required (Seguin 2001).

i. Intentional Overgrazing

In the season prior to planting, intentional overgrazing can help reduce competition but it requires close attention to avoid eliminating desirable species. The length of the grazing period and stocking rates must be closely monitored. If fencing is already in place, the cost of this suppression technique is minimal. Temporary high tensile electric fencing can be put in place for a reasonable cost (MAFRI 2006h). Grazing a vigorous sod only in the spring may be adequate for reducing above ground competition for sunlight but may not reduce the below ground root competition. Research at Lacombe, AB found that intensive grazing in the year prior to sod seeding alfalfa or cicer milkvetch was not enough to reduce the competition from bluegrass-dominated pastures (McCartney et al. 2007). However, this technique was more successful on bromegrass dominated sites.

In Quebec, sheep were used to graze a pasture dominated by smooth bromegrass and reed canarygrass to two or four inches high prior to sod seeding red or white clover. In addition, the sheep were grazed twice in the first 2 months after seeding - each time the grasses reached 10 to 14 inches. Compared to a 2.9 L/ac (356 g ai/L) application of glyphosate two weeks before seeding, the grazing resulted in similar densities of sod seed clover. However, competition from the existing stand was better controlled by glyphosate than grazing. Clover yields and forage quality tended to be higher when glyphosate was used compared to grazing (Seguin et al. 2001).

A study in Brookings, South Dakota found that heavy fall and spring grazing of a smooth bromegrass and Kentucky bluegrass pasture to less than two inches high was equal or better than suppression by an application of 0.6 L/ac (356 g ai/L) of glyphosate. However, it could take a large number of animals or a relatively long grazing period to achieve this on a large pasture (Smart et al. 2005).

ii. Mowing

Mowing can be as effective as overgrazing, without requiring the same level of management. However, it can be expensive and time-consuming to use on large areas. Mowing woody species can also leave sharp stumps that can harm cattle and equipment. Mowed vegetation should be removed, or else moisture and nutrients in the mulch will be available to the vegetation you are trying to suppress (PAMI & AFMRC 1993). Mowing can be done with a rotary flail or sickle mower – a rotary mower can shred woody plants up to six feet tall. A swather can be used where vegetation is not woody.

The best time to mow annual species is just prior to seed set, as their root reserves are lowest at this stage. The timing of seed set varies with the species. Perennial species should be cut before flowering and again if regrowth occurs.

A single mowing operation may not be enough to suppress existing vegetation. Research at Portage and Gladstone, MB showed that mowing a timothy or bromegrass/bluegrass pasture to two inches high immediately prior to spring seeding did not improve the establishment of sod seeded tall wheatgrass (Gobin 1995). Frequent mowing favours grasses over legumes and broadleaf weeds because the growing point of grasses is closer to the ground. Mowing will increase suckering of trees/ shrubs, so multiple treatments with more mowing, herbicide, or intensive grazing are required. Mowing two years in a row, or twice in one year if there is enough regrowth, is recommended (SAFRR 2002a).

iii. Burning

Burning is a useful suppression technique in some instances, but it is facing increased public scrutiny because of air pollution. Regulations must be complied with, and burning requires diligent attention to prevent fire risks to buildings, fences and trees. Make sure you have permission to burn. In Manitoba, contact a MAFRI GO Team office or centre or call 1-800-265-1233. Burning is inexpensive and provides rapid removal of existing vegetation. Heavily grazed areas are more difficult to burn successfully as at least 1000 kg/ac dry forage is needed to carry a fire evenly across a field (SAFRR 2002b). However, not all effects of burning are beneficial. Burning sometimes increases woody vegetation if pastures are subsequently under-stocked (PAMI & AFMRC 1993). Research information on burning has been compiled by Dr. Bailey and is available at www.foragebeef.ca.

iv. Spiking

Spiking is not frequently used as a sod-suppression method prior to sod seeding. There is little evidence that it is an effective suppression method. Research in Saskatchewan found that spiking to suppress sod was less successful than herbicide suppression (Schellenberg 1998).

c. Herbicide Suppression

Existing sods may either be temporarily suppressed by using lower rates of herbicide or may be virtually eliminated by using higher rates. A non-selective, non-residual herbicide should be used.

A University of Manitoba study at Gladstone and Portage la Prairie, MB found that dry matter production of sod seeded alfalfa in the year of establishment more than doubled when herbicides were used to suppress the existing stand. Differences were especially obvious at Gladstone, with alfalfa dry matter an average of 16 times higher than an unsprayed control when no phosphorus fertilizer was used, and 8 times higher when phosphorus was applied. During this study, the Gladstone site was drier than the Portage site and the reduced competition for moisture resulting from herbicide use is likely the reason for the dramatic effect (MAFRI 2006c).

Using herbicide usually results in a higher suppression of the existing sod than mowing or grazing. As a result, herbicide use may reduce the overall forage yield in the year of sod seeding and the following year compared to mowing or grazing (Seguin et al. 2001). Even though using herbicides to suppress existing vegetation may reduce the overall forage yield, the forage quality can be higher because the sod seeded legume seedlings make up a higher proportion of the stand. Too much suppression of the existing stand prior to sod seeding legumes may lead to a very high legume content and risk of bloat. It can also allow for weed encroachment (Seguin 1998).

i. Herbicide Selection

Glyphosate – Glyphosate (Roundup™) is the most commonly used herbicide for sod suppression prior to sod seeding. Other herbicides, particularly paraquat (Gramoxone™), have been used, but do not suppress sod as effectively as glyphosate (Seguin 1998). However, plants not controlled by glyphosate may increase after it is applied. In sod seeding trials in Saskatchewan, pasture sage was a minor species in a crested wheatgrass stand but increased dramatically after glyphosate application. Other perennial species like Canada thistle and sow thistle may also increase following a glyphosate application (SAFRR 2002a).

Recommended rates to terminate a forage stand with glyphosate in summer or fall are 1.5 to 2 L/ac (356 g ai/L) depending on the species. A rate of 1 L/ac (356 g ai/L) of glyphosate is commonly used for suppression prior to sod seeding. Some species are harder to control than others, particularly Kentucky bluegrass, creeping red fescue, orchard grass, meadow bromegrass, meadow foxtail, meadow fescue and smooth bromegrass. Grass species with fine leaves (such as creeping red fescue and Kentucky bluegrass) have a very extensive root system and are difficult to control with a single glyphosate application. The extensive root system allows the plants to regrow one or two months after treatment with glyphosate (Yoder 1999). Fall-applied glyphosate has been shown to be more effective for control of smooth bromegrass and bluegrasses (SAFRR 2002a).

Research in Minnesota and Quebec used glyphosate applied to smooth bromegrass and Kentucky bluegrass pastures 1 to 7 days before sod seeding kura, white, or red clover. Clover densities and dry matter production generally increased as the herbicide rate was increased. However, the higher rate of glyphosate at 3.7 L/ac (356 g ai/L) led to excessive grass suppression, resulting in weed infestation. A moderate rate of 0.9 L/ac (356 g ai/ha) did not result in weed infestation (Laberge et al. 2005a).

***Paraquat* -** Paraquat can be used to suppress sod growth; however, it is generally not as effective as glyphosate. Paraquat kills the above ground vegetation more quickly than glyphosate; but it does not kill the plant. Paraquat does not translocate to the roots so regrowth after paraquat application will occur more quickly than with glyphosate. This results in a shorter period of sod suppression compared to glyphosate. Research has shown that in Western Canada, using paraquat prior to sod seeding is not as successful as it is in Eastern Canada. In low moisture conditions typical in Western Canada, the suppression provided by paraquat is not always sufficient to allow new seedlings to compete for scarce moisture (Seguin 1998). However, it has been used to suppress vegetation prior to sod seeding in southern Manitoba (Bowes and Friesen 1967). Control with paraquat lasts for about three to four weeks, which may allow enough time for the forage seedlings to establish (MAFRI 2006b).

Different rates of glyphosate and paraquat for sod suppression of smooth bromegrass and Kentucky bluegrass pastures were compared at two locations in Quebec and three in Minnesota. Herbicide was applied 1 to 7 days before sod seeding kura, white or red clover. Glyphosate was more effective at suppressing sod than paraquat (Laberge et al. 2005a).

***2,4-D* -** In a Saskatchewan study, using 2,4-D in addition to glyphosate did not have any additional benefit in controlling existing vegetation prior to sod seeding, compared to glyphosate alone (Waddington 1992). In addition, 2,4-D residues can reduce survival of legume seedlings (MAFRI 2006a).

ii. Timing of Herbicide Application

For spring-applied herbicides, it is important that the vegetation be actively growing and treated at an early stage of growth (3 to 4 leaf stage) in order to optimize control. Spring application delays seeding compared to fall application.

Experience in Manitoba and Alberta has shown that late summer and early fall is the best time to control existing vegetation with herbicides (H. Yoder, G. Friesen, personal communication).

For a fall application, the vegetation must also be actively growing (e.g. not drought-stressed or after a frost). Spraying sod with glyphosate 3 to 7 days prior to the last cut or grazing operation works best. Six to eight inches of leaf re-growth should be present before spraying (Taillieu 2007).

Be sure to check the label of the herbicide you are using for any grazing restrictions. Many glyphosate products have short grazing restrictions of 3 to 7 days, depending on the rate.

iii. Spraying-seeding Interval

Glyphosate requires 14 days to completely desiccate grass, so some competition from the sprayed sod exists if seeding occurs during this period. A Manitoba study found that glyphosate application reduced growth of existing sod for approximately eight weeks, providing a window for establishment of seedlings (Bakker et al. 1997). While many studies have shown successful establishment of sod seeded species when seeded within two weeks of glyphosate application, some research has shown that increasing this interval can improve establishment. One study showed that increasing the time between glyphosate application 1.6 L/ac (356 g ai/L) and seeding from 7 days to 21 days significantly increased establishment of red clover; another study showed a similar effect for alfalfa when the interval was increased from 1 day to 28 days (Seguin 1998). It is possible that a delayed spraying-seeding interval may allow for leaching or inactivation of chemicals released from the killed grasses that harm legume seedlings.

Legumes should be planted into soils free of herbicide residues. Herbicide residues such as clopyralid (Lontrel™, Curtail™), and in some cases, 2,4-D, will reduce seedling survival of all legume forages (MAFRI 2006a). Be sure to check herbicide labels for replanting guidelines.

iv. Strip or Banded Herbicide Application

A broadcast application of herbicide can excessively suppress the existing stand, leading to reduced total forage yields in the year of sod seeding, weed encroachment, and high legume content with the risk of bloat. Several studies have tried applying herbicides in a band or strip to reduce these problems. In addition, if the seedlings fail to establish, there is still a part of the original stand that was not sprayed. Seeding into sprayed strips can be challenging if done in the fall, as there is little colour contrast between the killed vegetation and naturally dormant grasses (Malik and Waddington 1990). Research has shown that band applications of herbicides do not suppress the existing vegetation enough for successful sod seeding (Seguin 1998). Research in southwestern Saskatchewan has shown that the wider the sprayed strip, the better the establishment of sod seeded alfalfa (Schellenberg et al. 1994).

Other studies have not shown much advantage to banding herbicides compared to broadcast application. An experiment in Quebec used banded herbicide before seeding alfalfa into a bromegrass sod (Rioux 1994). Glyphosate was spring-applied in six-inch strips, 10 inches apart, and then alfalfa was seeded into the sprayed strips. This resulted in greater *total* forage production the year of seeding and fewer broadleaf weeds compared to a broadcast application of glyphosate in the fall. However, the alfalfa proportion of the forage yield was lower in the year of seeding with the spring banded herbicide compared to fall broadcast herbicide application.

Suppressing the Existing Vegetation

More suppression is required when:
- Species in existing stand are very competitive.
- Drier conditions (e.g. sandy soils).
- A higher density of the sod-seeded species is desirable (e.g. hayland).

Less suppression may be sufficient if:
- Few competitive species in existing stand, bare ground visible.
- Favourable moisture conditions.
- Sod-seeded species is bloat-producing and a moderate density is desired (e.g. pasture).

7. SEEDING

a. Seeding Date

The critical factor in the timing of seeding is moisture availability for the developing seedlings. In the spring, moisture conditions are generally better, but grass competitiveness is high. Conversely, in summer and fall grass competitiveness is lower, but soil moisture is also usually low (Seguin 1998).

i. Spring Seeding is ideal for germination and establishment because of the cool, moist conditions. However, excessively wet spring conditions, or weed control timing issues often limit this seeding period. Early seeding also makes seedlings more tolerant of grasshopper damage as they are more developed during peak grasshopper season (MAFRI 2006f).

ii. Summer Seeding can be very risky due to dry soil conditions. Summer seeding is approximately late July to mid-August. It is only recommended for those species that are known to establish easily with spring seeding, and if fall moisture conditions are expected to be favourable. If soil conditions are dry and there is no rain forecast, summer seeding should not be attempted. Summer seeding should be timed late enough to avoid hot mid-summer temperatures that stress young seedlings, but early enough for the plant to develop a crown before freeze-up (the crown is a small swollen area on the stem near the soil surface that makes the seedling more likely to survive the winter).

Legumes require a longer growing period than grasses to ensure winter survival, therefore, summer seeding of legumes is not recommended. Alfalfa requires approximately six weeks, and most grasses three to four weeks, to develop a crown. Chances of successful establishment are greater for grasses. Stands seeded in summer are more prone to soil heaving in late winter and early spring, especially if root development was limited due to slow germination or cool fall weather. Avoid summer seeding on heavier soils that have a history of alfalfa heaving (MAFRI 2006a; Bagg 2006).

iii. Frost seeding and Dormant seeding - these methods involve seeding forages in late fall, winter, or very early spring with the intention that seeds remain ungerminated until optimum temperatures exist in the spring. These seeds can germinate earlier than spring-seeded crops and make use of early spring moisture to better compete with existing grasses. The seed will be worked into the soil as it opens and closes with freezing and thawing in the spring. It can be a successful option when spring seeding is limited in areas susceptible to spring flooding.

Some legume species are not long-lived perennials but rather last three to four years (e.g. birdsfoot trefoil), and require allowing some plants to reseed themselves and maintain the species in the stand. As an alternative, it can be more economical to frost seed every three or four years than to set aside part of the pasture to allow it to go to seed (Harricharan and McKinley 1998).

The risk with these seeding methods is that seeds germinating early in the spring are susceptible to damaging spring frosts. If you frost or dormant seed a small percentage of your acreage each year, the risk will be spread over the years.

Broadcast dormant or frost seeding is most effective when some bare ground is visible. Stands dominated by bunch grasses are better sites. It is less successful in stands dominated by sod-forming grasses that produce a thick layer of thatch. Better seed-soil contact can be achieved with a secondary pass such as a harrow-packer in the spring. Alternately, allow animals access for a short time in the spring so that the hoof action can help plant the seed.

Frost seeding is broadcast seeding when the soil is already frozen or subject to frosts. A cyclone seeder on the back of a snowmobile or ATV can be used. It can be done on top of snow, and the pattern of sown seed on snow makes it easier to keep track of which areas have been seeded. The best time to frost seed is just prior to the frost coming out of the ground in the spring. Ideally, the ground should freeze and thaw at least two to three times after the seed is broadcast.

Legumes are most successfully frost seeded as they tend to be round and dense, allowing them to be worked into the soil more easily. Legumes also germinate at lower temperatures and will begin growth early in the spring. Species such as birdsfoot trefoil and clovers tend to be successful because of their harder seed coat. However, dormant seeding sweet clover is not recommended. Sweet clover seed is scarified to improve germination, but this can cause it to die during winter. Success with alfalfa can be variable as its seed coat is relatively soft and not as tolerant to freezing and thawing (Alberta Agriculture and Food 2006). Legumes should still be inoculated prior to seeding. The “hard” seed content in seed lots of legumes usually means the legume population thickens with time.

Figure 7. Broadcast seeding with snowmobile and ATV

Good populations of birdsfoot trefoil are often not seen until the second year following seeding (OMAFRA 2004, Quesnel and Kyle 2007).

Grasses can also be frost seeded, but this tends to be less successful than with legumes. In Ontario, frost seeding legumes is effective approximately 50-60% of the time, and grasses approximately 20-30% of the time (Harrichan and McKinlay 1998). Grass seeds are less dense than legume seeds, and when broadcast they are not as easily worked into the soil by freeze-thaw action. Species with fluffy or awned seeds are less likely to be worked into the soil by freeze-thaw action alone; harrowing or trampling by animal hoof action will be particularly helpful for these species. Grasses also need warmer temperatures than legumes to begin growth in the spring, which often coincides with less ideal drier weather.

A Wisconsin study found that while frost seeding grasses into bluegrass pasture was unsuccessful, grasses were successfully frost seeded into mature alfalfa stands in mid-March. The alfalfa was mowed the fall prior to seeding, and grazed or mowed to three inches high the following year whenever it reached 14 inches high. Nitrogen fertilizer (56 lb/ac) was applied 30 days after seeding. Perennial ryegrass was the most successful species, followed by orchardgrass and smooth bromegrass. Timothy and reed canarygrass were less successful (Casler 1999).

Dormant seeding is seeding the crop in late fall before freeze-up (late October or early November in most prairie locations). For this method to be successful, the soil temperature after seeding must be below 2°C to prevent germination. Seed can be lost over winter to rodent feeding. Seeding rates should be increased by at least 25 to 30 per cent to accommodate seed and seedling mortality. Fall dormant seeding systems work best with direct seeding into stubble, which insulates and protects the seedlings from early spring frosts (MAFRI 2006a).

A study in northeastern Saskatchewan successfully dormant seeded alfalfa and cicer milkvetch. An early fall glyphosate application followed by late fall sod seeding with a triple-disc range drill resulted in better establishment of alfalfa and cicer milkvetch than fall spraying and seeding the following spring (Malik and Waddington 1990). A study in North Dakota found that alfalfa seeded in early November produced successful stands two out of six years. In two of these years, alfalfa germinated in the fall and was killed over winter, highlighting the necessity of seeding late enough to avoid fall germination (Carr et al. 2004).

University of Manitoba research at Carman, MB investigated the use of polymer seed coatings to improve the success of dormant seeded ryegrasses, but it did not improve establishment in most cases (Bullied et al. 2003).

b. Seeding Rate

Higher than recommended seeding rates can improve the establishment of sod seeded seedlings, especially when the existing stand is very competitive or seeding conditions are not ideal. Keep in mind that even a stand in poor condition can still be very competitive with young forage seedlings. One study found that when the existing stand is very competitive, raising red clover or alfalfa seeding rates from 3.9 lb/ac to 15.7 lb/ac significantly increased legume yields in the year of seeding. However, with higher seeding rates, legume content can reach a level at which bloat can be a problem (Seguin 1998). A Manitoba study suggested doubling recommended alfalfa and cicer milkvetch seeding rates when sod seeding to establish denser stands more quickly (McCartney et al. 2007), and Alberta Agriculture and Food recommends increasing forage seeding rates by 1.5 times if seeding into recently terminated forage sod (Hutton et al. 2005).

See the Manitoba Agriculture, Food and Rural Initiatives factsheet, “Tips for Improving Forage Establishment Success” or your own provincial agriculture department for more detail on seeding rates (MAFRI 2006a).

c. Seeding Depth

Optimum Seeding Depth for Forage Seed for Different Soil Types

Soil Texture	Inches
Clay	¼ to ¾
Loam	½ to 1
Sand	¾ to 1.5

Source: MAFRI 2006a

Placing the seed too deep in the soil is a common mistake that results in stand failures. As an example, increasing the seeding depth for alfalfa from ½ inch to 2 inches can reduce emergence from 64% to only 14% (MAFRI 2006a). At the other extreme, you do not want to seed into the thatch layer as this does not allow for good seed-soil contact and conditions for germination are poor.

Most forage seeds are small and do not have enough food reserves to support growth from deep in the soil. In general, the smaller the seed, the more critical it is to seed shallow. However, coarse-textured, sandy soils require a slightly deeper seeding depth so seeds can access moisture. For most forage species, larger seeds that have greater seedling vigour are more likely to emerge successfully from deeper seed placement (Tesar 1984).

Check seed placement, seed coverage, and soil firming regularly as conditions are extremely variable when seeding into sod. The only way to check the seeding depth is to get off the tractor and physically check where the seed is placed. Ideally, check the depth in several adjacent rows. A general rule is that if a little seed cannot be seen on the surface, then the seeding depth is too deep. Seeding at too high a speed can result in uneven seed placement and less accurate depth control.

8. SOD SEEDING EQUIPMENT

Sod seeding equipment must be able to penetrate the litter layer and soil, place seed at a constant shallow depth, and pack soil around seeds. Consider the condition of the pasture or hayfield when choosing equipment. Equipment for sod seeding into the pasture must be heavy enough to ensure penetration of hard, uncultivated ground and have strong ground engaging parts for durability.

Bunch grasses like meadow brome tend to be easier to seed through than sod-forming grasses (SSCA 2005). Independent depth control or depth control bands on each opener will provide better seed placement in the uneven conditions typical of old pastures. Coulters will improve penetration of both disc and hoe type openers through heavy residue and firm soil. Press wheels should be used with all types of openers (Waddington 1992, Hutton et al. 2005). Seeds need moisture to start the germination process, but the top layer of soil can dry out very quickly. Packing improves seed-soil contact and slows drying of the soil (Tesar 1984).

Seeders designed specifically for sod seeding normally do a better job than modified

Ideal Sod Seeding Equipment Requirements

- Heavy equipment with good sod penetration.
- Independent depth control on each opener.
- Good packing qualities.

Figure 8. Drum Roller for Packing

grain drills. Manitoba research has shown that a Connor Shea Coil Tyne Coulter drill, designed for zero-till pasture renovation, is superior to no-till grain drills not designed for sod seeding (PAMI & AFMRC 1993). The Connor-Shea drill has been used in Manitoba's Interlake region primarily to sod seed into hayland. Modified grain drills should only be used in areas with thin sod and soft ground (OMAFRA 2004). Timing the seeding operation so that conditions are ideal is critical. Seeding early in the spring when the ground is soft allows for easier penetration by seeding equipment. This is especially important if you are using equipment that is not specifically designed for sod seeding. If glyphosate is being used to kill the existing sod, a fall application will allow the sod to decompose over winter, making it easier to seed into in spring (Taillieu 2007).

Disc or narrow knife openers with cutting coulters are generally best suited for seeding into sod. Hoe openers will tear the old sod leaving a rough surface. (Hutton et al. 2005). Triple-disc drills are often successfully used for sod seeding. Triple disc drills have one disc in front to cut into the sod, then a double-disc opener places the seed in the furrow (SAFRR 2002a). In dry conditions, the inverted "T" shaped slot created by a chisel opener is superior to "V" and "U" shaped slots created by double disc and hoe openers. However, when moisture conditions are good, few differences in seedling emergence are seen between these openers (OMAFRA 2004).

Research in Minnesota also suggests that when environmental conditions are optimal, the choice of seeding equipment has minimal effect on forage seedling establishment. Four different methods of sod seeding legumes (alfalfa, birdsfoot trefoil, red clover, and kura clover) into cool-season pastures were tested. Glyphosate was applied at 0.7 L/ac (356 g ai/L) prior to seeding. The seeding methods were no-till drilling, broadcast, broadcast + harrow, broadcast + light discing. Regardless of the seeding method, sod seeded legumes represented over one-third of the stand on average. Seeding method did not affect establishment, likely because environmental conditions were optimal during the experiment (Cuomo et al. 2001).

Other studies have shown more differences among seeding methods. A Manitoba study compared sod seeding with a single disc coulter system (Moore Uni-Drill) with 3 broadcast seeding methods. Glyphosate was

Figure 9. Connor Shea Coil Tyne Coulter Drill

Figure 10. Double Disc Sod Seeder

sprayed at a rate of 2.25 L/ac (356 g ai/L) the fall prior to seeding. Some plots were also sprayed with glyphosate in the late spring. A mixture of alfalfa, birdsfoot trefoil, red clover, tall fescue, meadow brome, and timothy was seeded into a bluegrass/quackgrass/broadleaf weed pasture near Tolstoi, MB (McCartney et al. 2007).

The seeding methods were:

1. Sod seeding with a single-disc coulter system (Moore Uni-Drill).
2. Broadcast seeding after using an AerWay tillage system (a rotary harrow spiked wheel that cuts into and opens up the sod plus heavy chain-link harrows).
3. Broadcast seeding after a heavy drag beam made from a steel “I-beam” was used to scrape the sod and expose the soil. A second pass was made after the seed was broadcast to cover the seed. The drag beam system can be home-made from scrap materials, and is also effective in clearing pasture with brush and small trees. The drag beam scrapes the bark off woody species and causes them to dry out (see Figure 13. &14.).
4. Broadcast seeding with no disturbance.

In the Manitoba study, using fall and spring glyphosate applications prior to seeding, plus P fertilizer, gave the best yields of sod seeded legumes. After two years, broadcast seeding plus disturbance with the AerWay tillage system or drag beam resulted in a higher percentage of seeded species compared to seeding with the Moore Uni-Drill. The drag beam system did have the lowest levels of establishment, but by the second year it along with the AerWay tillage system had better establishment over the Moore Uni-Drill, especially when 40 lb/ac P fertilizer was applied. However, research in Saskatchewan showed that if the AerWay tillage system is used to disturb the soil after broadcast seeding, the seed was often buried too deep (McCartney et al. 2007).

Figure 11. & 12.
AerWay Rotary Aerator

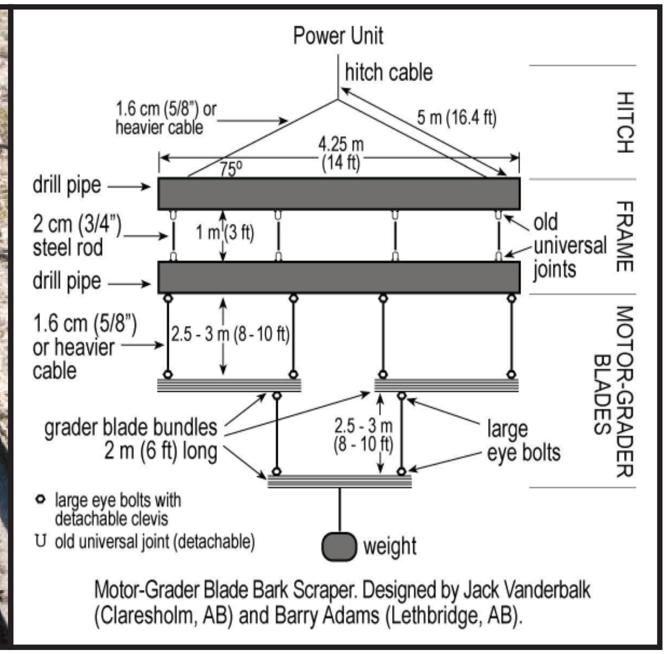


Figure 13. & 14. Drag beam and diagram of drag beam construction.

A Saskatchewan study compared six drills for sod seeding legumes at multiple locations (Waddington 1989; 1992). Machines using three different furrow-opening methods were tested: two hoe types, three ground-driven disc types, and a powered cutting-disc type. Alfalfa was dormant-seeded in late fall into grazing lands where strips had been killed with glyphosate.

The following six sod seeding drills were used in the Saskatchewan study:

1. Triple-disc range drill - fluted rolling coulter followed by double-disc opener (designed for Agriculture Canada Swift Current Research Station).
2. Rotary disc driven from PTO – John Deere Power-Till Seeder.
3. Double-disc zero-till seeder - vertical rolling coulter with offset disc opener (designed for Agriculture Canada Swift Current Research Station for seeding forages).
4. Zero-till hoe drill - high clearance, narrow hoe opener designed for seeding cereals into cereal stubble (designed for Agriculture Canada Swift Current Research Station).
5. Single offset disc opener – Moore Unidrill (designed in Northern Ireland for general seeding).
6. Rolling coulter followed by narrow winged hoe opener – Connor-Shea hoe drill (designed in Australia for zero-till pasture renovation).

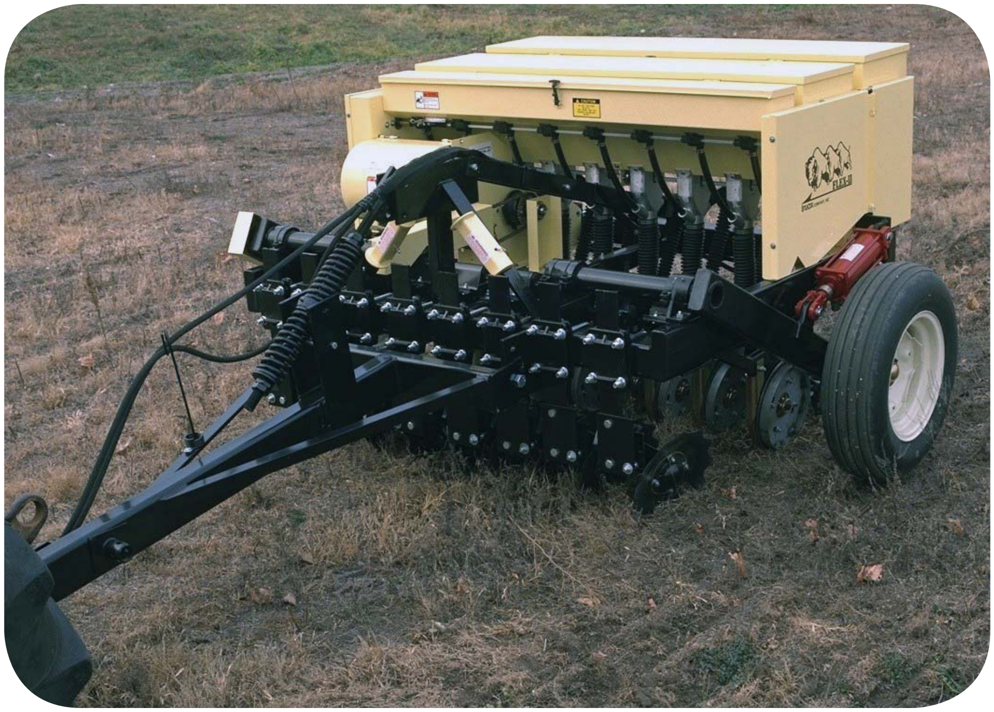
Figure 15. a & b Moore Uni-Drill Single Angled Disc Seeder

All of the six drills tested in the Saskatchewan study were successful in some situations. The type of furrow opener was not critical, but good depth control and enough weight for penetration of the sod was essential for good seed placement. The best emergence was with heavy drills with independent depth control on individual openers. Packing the soil around seeds was also important. In addition, when several seeding components were used together (rolling coulter, furrow opener, packer), rigid alignment was important. In hard, stony conditions these components can shift slightly, resulting in openers that are no longer aligned with coulters or packers.

The study found that the triple-disc drill was the most consistent in successfully establishing sod seeded legumes. Its weight was heavy enough to penetrate even in dry soil conditions, and independent depth control on each opener allowed for good seed placement in uneven ground. The triple-disc drill also had heavy packer wheels that provided good seed-soil contact. These packer wheels have a U-shaped cross section that closes furrows with pressure, mostly from the sides.

The double-disc zero-till seeder, Connor-Shea drill, and Moore Unidrill were not heavy enough to penetrate the dry, hard soil. The Connor-Shea drill also had poor depth control in the middle of the drill because seeding depth is regulated by the wheels at each end of the frame. The Moore Unidrill's seed metering mechanism was easily plugged by debris when set to forage legume seed size; however, it may work better for grass-legume mixtures. The Moore Unidrill's disc and packer are mounted on a common bar, assuring good alignment even in stony conditions. The zero-till hoe drill openers worked well when at the right depth; however, the depth reference points were about 3 metres apart, so that in uneven ground the hoes frequently ran too deep or out of the ground. The packing wheels on the John Deere Power-Till seeder were too narrow and light to be effective, and the discs wore quickly in hard, stony soil.

In a different Saskatchewan study, a Truax sod seeding drill with double-disc openers and trash ploughs to push litter aside was used to successfully seed several legume species under ideal moisture conditions. Cicer milkvetch, birdsfoot trefoil, or purple prairie clover were seeded into a smooth bromegrass/alfalfa stand following a 2 L/ac (356 g ai/L) spring glyphosate application. Establishment of these species was good to excellent. However, the trash ploughs disturbed the soil enough to cause a flush of weeds in and near the sod seeded



rows. A flush of weeds was not seen in previous research with a triple-disc seeder without trash ploughs (SRC 1996a).

Another Saskatchewan study (SRC 1996b) used a Truax grass drill to sod seed alfalfa with a tame grass or a mixture of native grasses into three different pastures. The pastures were dominated by bluegrass, smooth bromegrass, or crested wheatgrass and each contained some alfalfa. Glyphosate at 3 L/ac (356 g ai/L) was used for suppression. The drill had notched coulters that lift and turn the litter aside, followed by double disc openers with packing wheels. This seeding method was successful in increasing the percentage of alfalfa when it was seeded with tame grasses in the bluegrass and crested wheatgrass pastures. However, this method of seeding alfalfa was not successful in the smooth bromegrass pasture because unforseen conditions caused the alfalfa to winterkill.

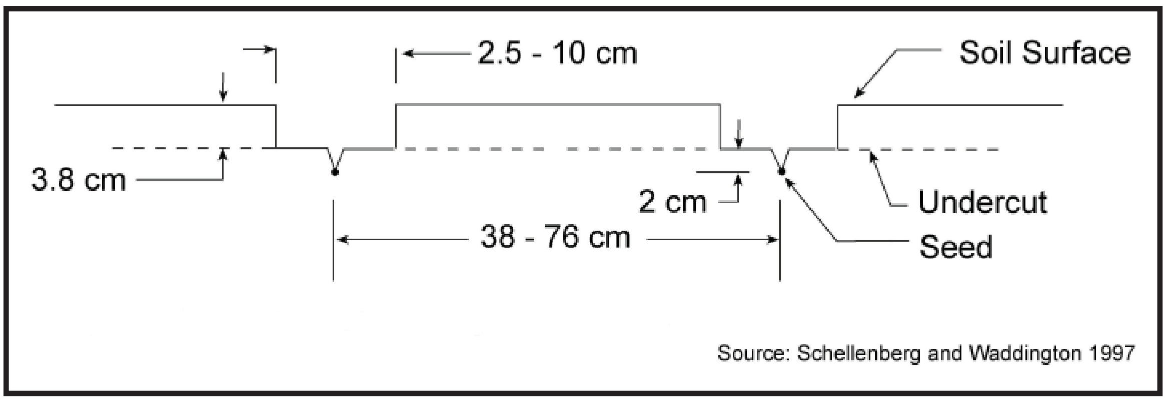
Figure 16. a and b
Truax No-till Drill

9. OTHER SEEDING METHODS

a. Slotseeding versus Sod Seeding

Slotseeding refers to removing a strip of sod (one and a half inch deep) to create a “slot” that is free from competition from the existing pasture species. Forages are then seeded into a furrow in the centre of the slot.

A study in Swift Current, SK compared sod seeding to slotseeding. Alfalfa was sod seeded into a crested wheatgrass stand after suppression with 2.5 L/ac (356 g ai/L) glyphosate. This method was compared to several widths of slotseeding that were **not** suppressed with glyphosate. Four widths of “slots” were tested (1, 2, 2.8, and 5 inches). In addition, two widths of grass (6 and 14 inches) adjacent to the slot were undercut and evaluated to determine their effectiveness in further suppressing the sod. Results showed that alfalfa sod seeded after suppression with glyphosate had a higher survival rate and greater productivity than any of the slotseeding and undercutting methods. As a result, slotseeding is not recommended.



Legend: 3.8 cm = 1.5 in, 38-76 cm = 15-30 in, 2 cm = 0.5 in, 2.5-10 cm = 1-4 in

Figure 17. Slotseeding technique used in the study.

b. Using Livestock to Seed New Forage Species

A low-cost way to get legume seed into pasture is to let the cattle distribute it for you. Livestock digest all of the grass seed and most of the legume seed they eat (Peterson 2002). However, some “hard” legume seeds remain viable as they pass through the cattle’s digestive tract. The seeds will pass through in 24-72 hours, but they do not germinate in freshly excreted manure. Manure must first break down and become thinly distributed on the soil.

Cattle can be fed legume seeds by adding it to grain or mineral mixes. These areas should be established at a distance from water, salt, and mineral supply to ensure good distribution of feces. However, cattle do not distribute manure uniformly and will produce less uniform stands than other seeding methods. A less successful technique is feeding mature hay containing seed because usually only a small amount of seed is ingested by the animals. Alternately, add 0.5 kg of legume seed to each load of manure being spread on pastures (OMAFRA 2004).

Reasons for Seeding Failures

SEEDS FAIL TO GERMINATE
• Soil too dry or moisture levels fluctuate too widely. • Too cold for germination. • Seed is dormant or not viable. • Not enough air - seeds sown deeply in wet, heavy soils don't have enough oxygen.
SEEDLINGS DIE AFTER GERMINATION
• Seed placed too deep – seedling does not have enough energy to emerge. • Shallow seeding with insufficient packing, or seed placed in thatch layer – seeds may germinate, but as the soil surface dries out the seedling dies. • Toxicity from herbicide residues in soil or seed contact with fertilizer. • Crusted soil surface – seedlings cannot break through.
SEEDLINGS DIE AFTER ESTABLISHMENT
• Competition from existing vegetation for moisture, nutrients, and sunlight. • Drought or flooding. • Grasshopper damage. • Winterkill – seeding too late in fall, or using poorly adapted cultivars. • Species/cultivar not adapted to conditions such as salinity, pH, drought tolerance or winter hardiness. • Legumes not properly inoculated.

Source: Adapted from Heath et al. (1985)

10. MANAGEMENT AFTER SEEDING

a. Grasshopper Control

High grasshopper populations can result in poor stand establishment on sod seeded sites. Monitoring of grasshopper populations along field edges and roadsides should begin in late May so that high populations can be controlled early in the season. Early control of young grasshoppers is more effective than adult grasshoppers. Also, earlier in the summer insecticides can be effective if applied just to field edges or roadsides rather than entire fields. Keep in mind that warm, dry summer and fall weather allows for greater numbers of grasshopper eggs laid and earlier hatch of eggs in the spring. Over several years, warm, dry weather can lead to grasshopper outbreaks.Overgrazing pastures promotes grasshopper abundance because open patches of bare ground make excellent egg-laying sites. Earlier seeding and good growing conditions will make the young seedlings more resistant to grasshopper damage (MAFRI 2006f).

b. Grazing after Seeding

The regrowth of the suppressed sod is typically faster than the growth of the new seedlings (Peterson 2002). Grazing or mowing the re-growing sod before the grasses grow over developing seedlings will reduce competition. Many producers fear damaging seedlings by early grazing, but if managed properly, fewer seedlings are harmed by excess grazing versus competition from existing vegetation if it is not suppressed (Leep et al. 2003). The grass should be kept short using grazing or mowing until the legume plants reach three to four inches high. However, if the soil is wet, delay grazing to avoid damage to seedlings by trampling. Grazing is best done with a one to three day grazing period (i.e. “flash” or “mob” grazing). Once the animals start to bite off young legume leaves, stop grazing for several weeks to allow the new plants to become established. Rotational grazing should then be used to keep the canopy fairly open, allowing sunlight to reach the legume seedlings (SSCA 2005).

Grazing management for establishing a warm-season grass into an existing cool-season grass is very similar to management for legume establishment. Establishing grasses are not quite as sensitive to grazing pressure as new legumes because the grasses growing point is at the base of the plant while the legumes growing point is near the top.

Tips for Successful Germination and Emergence of Sod Seeded Forages

- Soil test and apply fertilizer as required, especially P.
- Suppress competition from the existing vegetation, especially in drier soil conditions.
- Use seeding equipment appropriate for sod seeding conditions.
- Packing will slow drying of the soil and allow seeds to take up water more easily.
- Plant shallow according to soil type – small seeded forages don’t have enough energy stored in the seed to emerge from deep plantings.
- Check seeding depth and packing regularly while seeding.

11. SUMMARY

Considerable research has been done on various aspects of seeding forages into existing stands using minimal tillage. The research has been summarized in this document and also on www.foragebeef.ca. Control or suppression of existing vegetation, especially bluegrass, is of primary concern. This can be done through the use of grazing prior to and after seeding in addition to the use of glyphosate herbicide. The use of phosphorous fertilizer will enhance seedling germination and establishment. Using the methods outlined in this publication will lead to successful forage stand rejuvenation over a period of years.

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