Sod and Mob Seeding of Legumes - 2016

Introducing Legumes into an Existing Forage Stand Using Sod and Broadcast Seeding and Mob Grazing Techniques

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Introduction and Objectives

The First Street Pasture is poor quality land. Much of it is Class 4 and 5 land with rapidly draining, coarse, and infertile soils, made worse by historical cultivation. It is dominated by smooth brome, Kentucky bluegrass, and leafy spurge, and generally of low livestock carrying capacity.

Legumes (e.g. alfalfa, clovers, vetches) in pasture are prized as a source of protein and minerals, and for adding fertility (via atmospheric nitrogen fixation) to soil. The First Street Pasture, when acquired by MBFI in 2015, had only sporadic alfalfa and sweet clover. Feed tests from grassy areas at First Street Pasture over recent years, have shown that some important quality factors are borderline or short of meeting the needs of post-partum lactating cows. Soil samples taken in 2015 on the First Street pasture showed needs for improving soil fertility. Nitrogen and sulphur had a very low nutrient status in the top 12 inches; phosphorous was low to very low but potassium had a high nutrient status in the top 6 inches. Organic matter is low to medium.

Increasing legume content at First Street Pasture is expected to improve yield and forage quality. However, forage stand rejuvenation is an expensive and risky procedure. Manitoba Agriculture estimated the 2021 operational and labour costs (excluding land and equipment value) to just establish an alfalfa-grass stand were estimated to be $225.17 per acre before any income from it. Not all grazing lands are arable lands suited to conventional stand establishment methods. At First Street Pasture, like many lands in western and central Manitoba set aside for pastures, the sandy soil makes it risky to kill and replant, due to periods of dryness, wind erosion, and higher chances of grasshopper infestations4. Some success has been obtained by sod seeding or using cattle hoof action to incorporate the seed into existing grass stands. The practice is not that common however, and questions that are often asked include: When should I seed? What can I expect for establishment? Is there enough establishment to have a meaningful benefit to the stand and therefore livestock production?

MBFI, from 2016 to 2018, created a research and demonstration project at First Street Pasture to compare 2 methods of direct seeding against just fertilizing with phosphate or sulphate, or doing nothing. Follow-up data were collected in 2019 and 2021. There were four objectives:

- Plant alfalfa into an existing grass stand and compare success rates against simply fertilizing the existing legume population with phosphorus and sulfur, or doing nothing.
- Determine, if the alfalfa establishes successfully, if there are significant yield increases, compared with only fertilizing the stand or doing nothing.
- Determine, if the feed quality is better than the fertilized or control plots.
- Review the cost of implementing these practices, and compare against the value of the productivity change to justify this practice.

Methods

Background legume counts were made prior to planting, and additional data were used from the 2015-2017 EXT17 Simple Rotational Grazing Effects project, where plant species composition in other First treet Paddocks was estimated as part of a pasture health assessment.

This project experimented with two methods of direct seeding:

1. mob grazing followed by drilling seed into pasture (10-ft International 620 double-disc press drill, 12.5 lb/ac of inoculated alfalfa)
2. broadcast seeding (quad-mounted spin spreader, 12.5 lb of alfalfa), followed by mob grazing.

These two seeding methods were tested in 0.9 acre plots, in each year from 2016 to 2018, and compared against simply adding fertilizer (phosphate and sulphate) or doing nothing (Figure 2,3).

Fertilizer was applied to the seeding and fertilizer only treatments (according to soil tests):

1. before seeding in early June of each year, broadcasted on seeded and unseeded+fertilized plots:
   a. 30 lb/ac of phosphorus from monoammonium phosphate (11-52-0-0)
   b. 15 lb/ac of sulphur from ammonium sulphate (21-0-0-24)
   c. nitrogen (ammonium) was an incidental part of the above fertilizers, and
2. elemental sulphur (11 lb/ac) added to alfalfa seed in both drilling and broadcasting plots to bulk it for seed rate control (bulk); it is very slow to benefit legumes, so is not considered a treatment factor within the timeframe of this project.

Drill Directly	Broadcast & Mob	Do Nothing	Just Fertilize	Do Nothing	Drill Directly	Just Fertilize	Broadcast & Mob	2016
Just Fertilize	Do Nothing	Broadcast & Mob	Drill Directly	Broadcast & Mob	Do Nothing	Drill Directly	Just Fertilize	2017
Broadcast & Mob	Just Fertilize	Drill Directly	Do Nothing	Just Fertilize	Broadcast & Mob	Do Nothing	Drill Directly	2018

Figure 2 – Plot design. Each row is one year of treatments. Three treatments and a control (non-treatment) are replicated twice, and shuffled. Diagram is not to scale.

Figure 3. Cattle mob seeding and suppression, and direct seeding with press drill.

Grazing was used in early June:

1. prior to drill seeding to reduce aboveground biomass and suppress existing plants
2. after broadcast seeding to reduce aboveground biomass, incorporate seed, and suppress existing plants
3. on all other (unseeded and unseeded+fertilized) plots around the same time.

There were 55 mixed heifers and cows in 2016, 56 in 2017, and 99 in 2018. Each plot was 0.9 acres and grazed for approximately one day each, except for less time in 2018 which had more animals and less orage due to the dry spring. Forage was a mix of old residue and new growth.

Grazing was also applied:

4. on half of each plot in fall of the planting year (to determine impact of grazing in the first year),
5. on entire plots seeded in the prior years, and fertilized or control plots, in late June to early July,
6. on entire plots seeded in the prior years, and fertilized or control plots, in early fall to take advantage of regrowth, but avoid the sensitive late summer window for alfalfa.

The same number or fewer animals was used as in the planting treatments described above, but at lower density and percentage utilization.

Measurements from 2016 to 2018 were:

1. germinated seedling counts approximately 30 days after planting
2. established stem counts in fall of planting year and every year after
3. productivity of all plots in summer and fall
4. stand forage quality in summer and fall.

Some follow-up was done in 2019 and 2021. This Final Report will compare the 2016 to 2018 data to the 2019 to 2021 data.

Legume germination and establishment were evaluated with 5 to 10 counts in each plot in a W or V formation, and using square-foot frames. Productivity and feed testing was done with 3 to 4 clipping samples in each plot, in a V formation, using 50 cm x 50 cm frames. Productivity was sampled again in fall 2021 for all plots excluding the 2018 planting year which had failed to catch an alfalfa stand. Forage quality samples were taken in July and September of 2020 and 2021, and composited by the alfalfa-dominated seeded plots and the grass-dominated non-seeded plots. Both basic feed quality (Central Testing 2FF) and micronutrients (FFMP) were analysed.

Spring and summer rainfall data from the ECCC weather station at Brandon Airport were summarized to help explain germination and establishment rates. Daily precipitation during spring and summer of each year was plotted. Total monthly precipitation (mm) and number of days with precipitation greater than 5, 10, and 25 mm were determined.

Methods for the Return on Investment analysis are detailed in a later section.

Results

Frequency is a measure of how often you may encounter an alfalfa plant (basically yes or no in a sample). The pre-seeding legume count samples for this project showed:

- 1 of 128 samples had alfalfa
- 26 of 128 samples had black medick (a low-growing alfalfa look-alike)
- 33 of 128 samples had sweet clover
- 6 of 128 samples had a native legume (milkvetch or American vetch)
- 1 of 128 samples had white clover.

The data from the EXT17 Simple Rotational Grazing System Effects project found more all legumes except sweet clover had higher frequency:

- 3 of 50 samples had alfalfa
- 34 of 50 samples had black medick
- 1 of 50 samples had sweet clover
- 3 of 50 samples had a native legume (milkvetch).

After seeding, frequency of alfalfa increased greatly only for the 2016 and 2017 seeded plots (Table 1), regardless of

type of planting method used. In the 2018 plots, frequency increased only a small amount due to planting failure, likely influenced by poor patterns of rainfall during the year of planting.

Measurement	Baseline in C	Baseline in D, E, F	Current Seeded in 2016	Current Seeded in 2017	Current Seeded in 2018
Alfalfa Frequency	1 of 128 (<1%)	3 of 50 (6%)	24 of 25 (96%)	23 of 25 (92%)	2 of 25 (8%)

Table 1. Alfalfa frequency before any planting, compared with current alfalfa frequency on seeded areas. Baseline frequency was measured in 2016 and 2017, while current frequency on seeded areas was measured in 2021.

Results for germination and establishment counts are in Table 2. Average counts of seedlings one month after germination were better in the broadcast & mob seeding method than in the mob & drill method for 2016 and 2017. Germination was poor in 2018. With the soils on First Street pasture being so deficient, the fertilizer (phosphorus and sulphur) impacted initial seedling growth on the alfalfa plantings, but also promoted the growth of resident legumes and grasses on all treated plots.

Broadcast and mob also had better establishment counts than drill by the fall of the 2016 and 2017 planting years. In most cases, as we should expect, some of the germinated stems die off. In only one case, a broadcast planting gained stems going into fall (the 2016 broadcast & mob). This could be due to either late germination or not enough sampling to give a good average for the patchy seeding that happened with the broadcast spreader.

By 2021, in the 5th or 6th summer, the stem densities of the 2016 and 2017 plots have stabilized at about 16.4-17.8 stems/ft2. Compared with standards for an acceptable stand (40 or more stems/ft2), this rates as weak. However, we need to consider 2 things:

1. this isn't commercial alfalfa production on arable land: it is on coarse soil, susceptible to frequent dryness, which would limit the site's capacity to support a high number of alfalfa plants
2. this pasture started out under 10% alfalfa frequency, and now increased to over 90% frequency in the successful seeding years; it meets the goal of increasing legume content of pasture.

Treatment	Seedlings Summer #1	Establishment Fall #1	Establishment Summer #2	Establishment Summer 2021
2016 Mob & Drill	8.9	▼ 6.5	-	17.0
2016 Broadcast & Mob	13.4	▲ 20.1	-	16.4
2017 Mob & Drill	17.5	▼ 4.8	5.2	17.8
2017 Broadcast & Mob	28.2	▼ 13.4	10.3	17.2
2018 Mob & Drill	2.7	▼ 1.5*	0	0
2018 Broadcast & Mob	2.3	▼ 0.2	0	0.9

* Present in only 2 of 40 frames, one with 54 stems

Table 2. Alfalfa stem counts (/ft2) in their first summer, then total stems the same fall and following summer, and then stems in summer 2021, for the two seeding methods tried over 3 years. Number of samples averaged is variable among the different datasets (10, 20 or 40).

At present, the stand is healthy, but over the long term, it would be important to continue tracking alfalfa stem densities, and also to include sampling crown health by cutting through it to see if it issymmetrical with plenty of live shoots and if there is plenty of white flesh instead of excessive rot.

Figure 3 shows the 2021 forage productivity of all 2016 and 2017 plots. Total forage production (in this case, July peak production plus regrowth to October) was higher on the 2017 experimental site than the 2016 experimental site for all treatments (the 2017 experimental site possibly has better soil conditions). Between the two alfalfa planting methods in either year, there wasn't much difference, and the fertilizer only plots were only slightly more productive than the do-nothing plots, both well below the productivity of the alfalfa plantings.

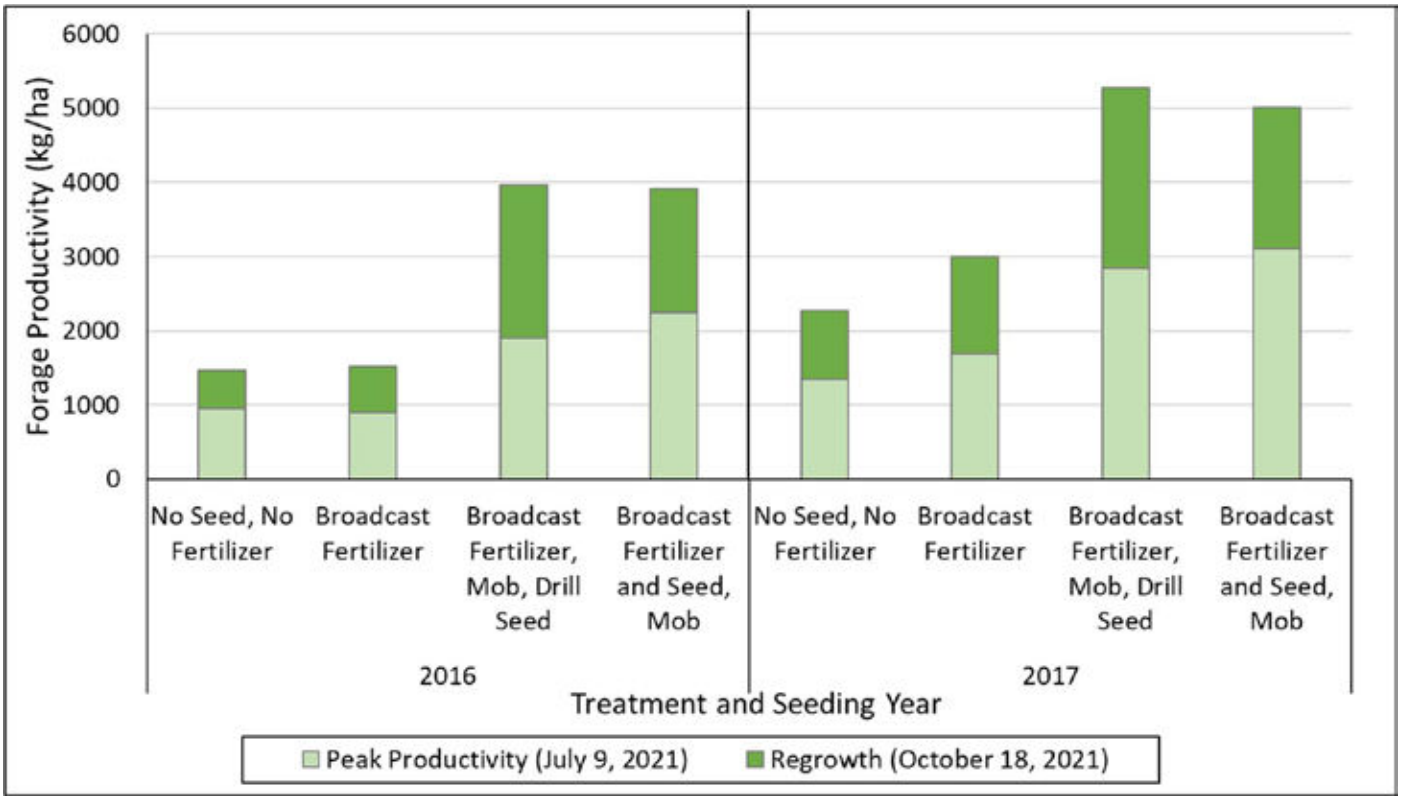

Figure 3. 2021 forage productivity comparison among seeded and unseeded plots established in 2016 and 2017. Each average is composed of 6 subsamples (3 frames in each of the 2 plots with that treatment). The 2018 plots were not sampled because the planting failed.

Casual observations in 2020 and 2021suggest that alfalfa cover in the 2016 and 2017 seeded plots is easily over 90%, with occasional thin patches. The 2021September air photo also shows good coverage. The alfalfa content of the stand is so good compared with the rest of the pasture that MBFI mitigates risk of bloat by grazing only after bloom, and by dividing cells so they have mixed grass and alfalfa cover. Avoiding grazing during the late summer critical period has also helped to maintain stand health.

A soils report and older airplane/satellite imagery (Figure 5) suggest that there are different soil surface conditions in the westernmost 2018 plots than elsewhere in this project. This soil is also of coarse texture, but occurs on hill to upper slope positions, making it less developed, less fertile, more rapidly drained, and more sensitive to drought and wind erosion. The collection of imagery in Google Earth suggests a different soil surface operation occurred long ago (Figure 5). But still, a closer look at the map shows that better soil does occur in the easternmost 1/3 of the 2018 planting, yet alfalfa plots there also failed. Both soil surfaces, being coarse-textured with low water holding capacity, would have been especially sensitive to the poor rainfall patterns that were seen in 2018.

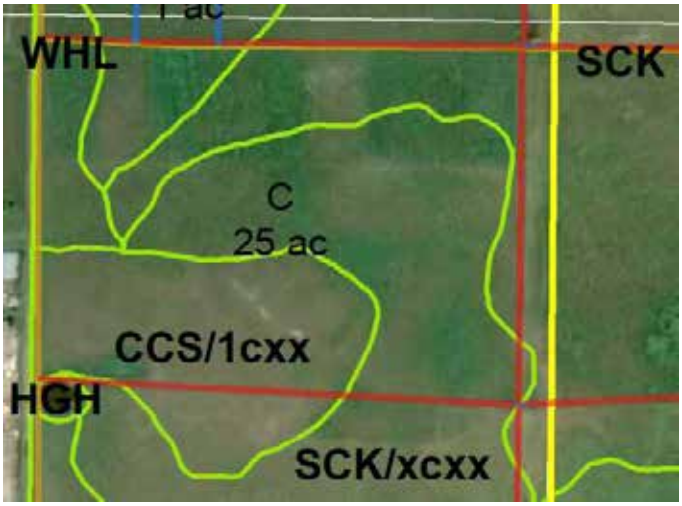

Figure 5. On left, soil map coverage (green line) of Paddock C (bordered by the red line) at First Street Pasture. CCS = Cactus Loamy Fine Sand (less developed); SCK = Stockton Loamy Fine Sand (more developed). On left, a winter image from Google Earth showing a very old soil surface disturbance in western 2/3 of the 2018 planting area. Manitoba Soil Survey Outlines and Image Data from Manitoba Land Initiative © His Majesty the King in Right of Manitoba; Winter Imagery Data from Google, © 2023 Maxar Technologies.

The relationship between rainfall and establishment success is complex. Rainfall is required to soften the surface for ideal planting by seed drill or by cattle hooves, and then continuing afterward for germination and survival. Sandy soil doesn't hold moisture well, so a regular occurrence of small and edium rainfall events, with occasional soaking rains, is better than occasional large events. Table 3 summarizes monthly precipitation (mm) and number of days with precipitation greater than 5, 10, and 25 mm (2 tenths, 4 tenths, and 1 inch) and Figure 6 shows patterns of daily precipitation and planting and counting dates10. The most regular and abundant rainfall happened in 2016, then not as much in 2017. In 2018, rainfall wasn't regular enough during the critical germination period. Even if germination was delayed past the counting period, the hot, dry month of August would have failed those seedlings.

Year		April	May	June	July	August	September
2016	rain (mm)	33.6	56.4	106.4	98.0	48.6	90.2
	# > 5mm	4	3	6	6	2	5
	# > 10mm	2	3	4	3	2	4
	# > 25mm	0	0	1	2	0	1
2017	rain (mm)	16.2	21.4	70.6	36.0	37.4	79.2
	# > 5mm	1	1	5	2	3	5
	# > 10mm	0	0	2	1	1	3
	# > 25mm	0	0	0	0	0	0
2018	rain (mm)	5.4	24.0	85.2	52.6	25.4	59.4
	# > 5mm	1	1	4	2	1	5
	# > 10mm	0	0	2	2	1	2
	# > 25mm	0	0	2	0	0	0
Normal	rain (mm)	25.8	59.1	80.7	73.4	65.9	43.7
	# >= 5mm	2	4	5	4	3	3
	# >= 10mm	1	2	3	2	2	2
	# >= 25mm	0	0	1	1	1	0

Table 3. Summary of rainfall amounts and numbers of days of significant rain events during the Sod and Mob seeding project at First Street Pasture, including normal from 1981 to 2010.

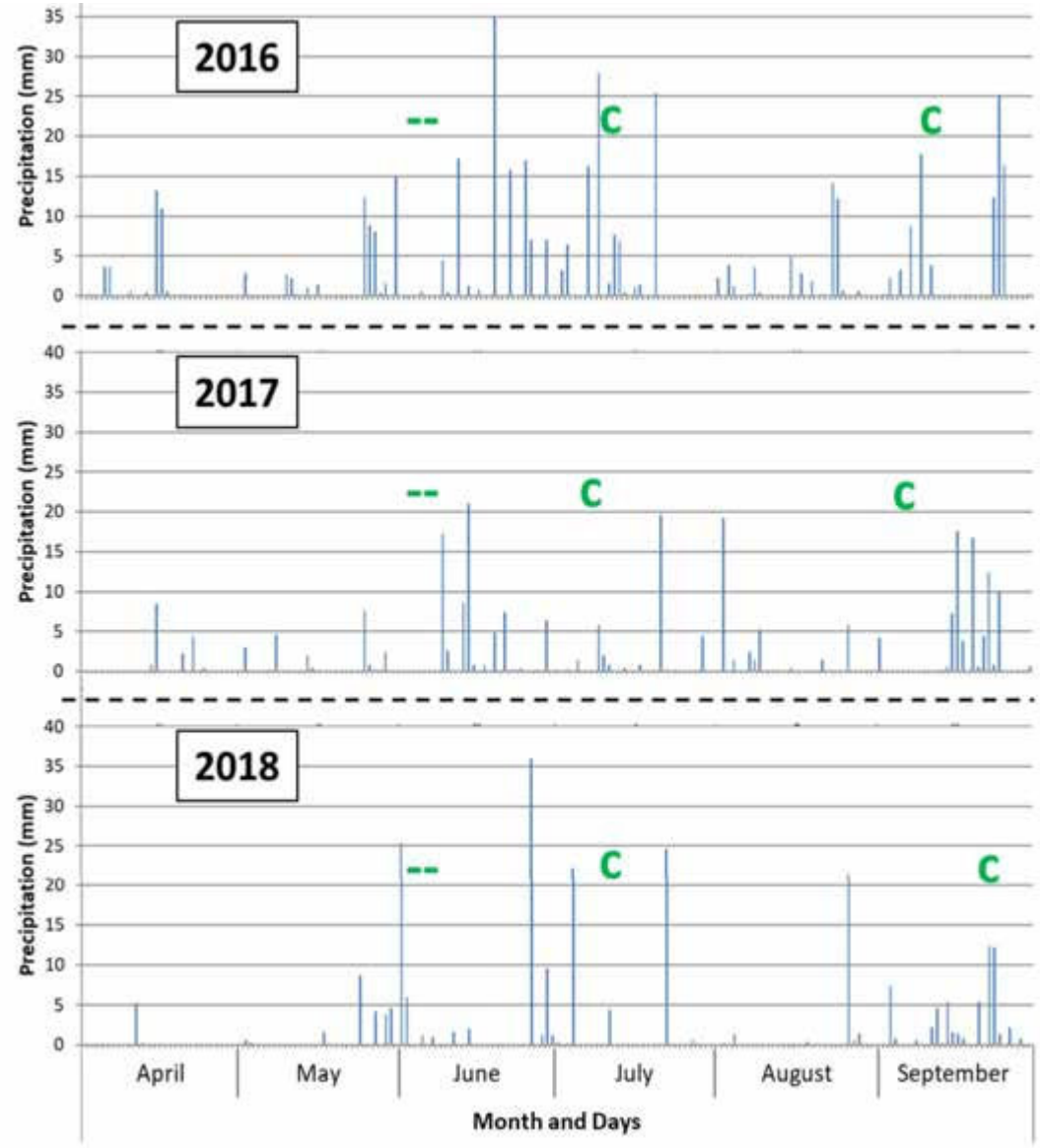

Figure 6. Precipitation patterns in spring and summer during 3 years of the Sod and Mob seeding project10. Seeding was in early June over 5 to 8 days, roughly indicated with a "--". Germination and established seedling counts happened in July and September on the approximate days indicated with a "c". 25mm = 1 inch.

Figures 7, 8, and 9 compare forage quality and nutrient content in late June and mid September among the seeded alfalfa pastures (both drill and broadcast sampled together) and the grassy pastures (fertilized and non-fertilized sampled together). The 2018 plots were omitted because the alfalfa failed o catch and persist there. Alfalfa pasture samples did have some grass in them but from observation, samples were at least 80% alfalfa.

Alfalfa stands had better crude protein than grass, to the point that it would easily meet the needs of post-partum lactating cows. Total Digestible Nutrients is generally not meeting postpartum needs but borderline at meeting later summer needs. Keep in mind that the whole plant is sampled in this process, but the cow generally eats only the leafy and upper parts and is probably getting somewhat better feed value than this.

Alfalfa is increasing calcium, magnesium, and potassium in the cattle diet. Phosphorus did not seem to increase much, and sodium did not increase. Calcium, phosphorus, and potassium requirements are being met easily on alfalfa or grass pasture. Magnesium is borderline, better in later summer when demands are lower, but sodium is not met. Again, considering that the cow only eats the leafy portion of the plant, she may be faring better than the test indicates.

Alfalfa is adding zinc and copper to the diet, but not enough to meet minimum requirements. Iron and manganese were reduced in alfalfa pasture. All pasture has enough iron and manganese, except June 2021 alfalfa pasture which falls short of minimum requirement, but is covered by mixing with the grassy pasture.

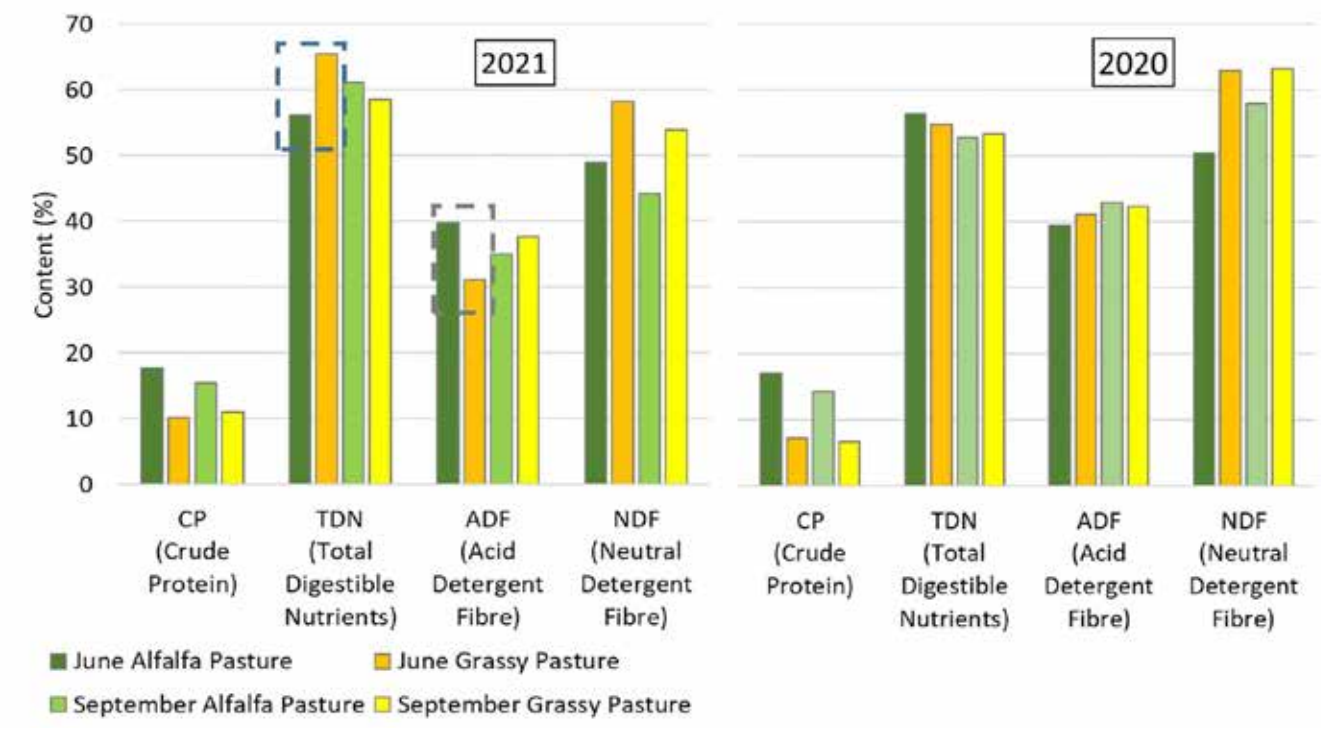

Figure 7. Protein, nutrients, and fiber content of alfalfa versus grassy pasture in Paddock C at First Street in late June and mid September of 2020 and 2021. The dashed box indicates a possible anomaly in the test which is why the 2020 results are included. Eight subsamples are taken from among all alfalfa or non-alfalfa plots, and composited into one sample for the test.

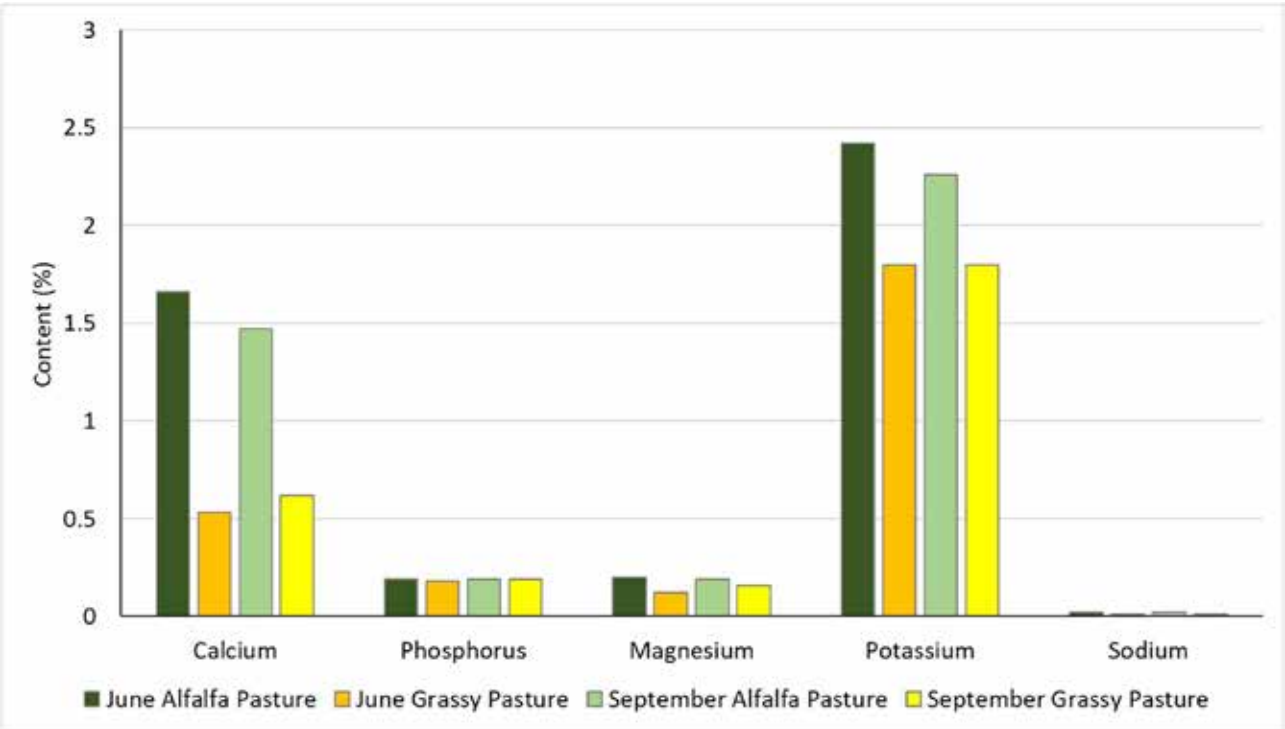

Figure 8. Mineral content of alfalfa versus grassy pasture in Paddock C at First Street in late June and mid September of 2021. Eight subsamples are taken from among all alfalfa or non-alfalfa plots, and composited into one sample for the test.

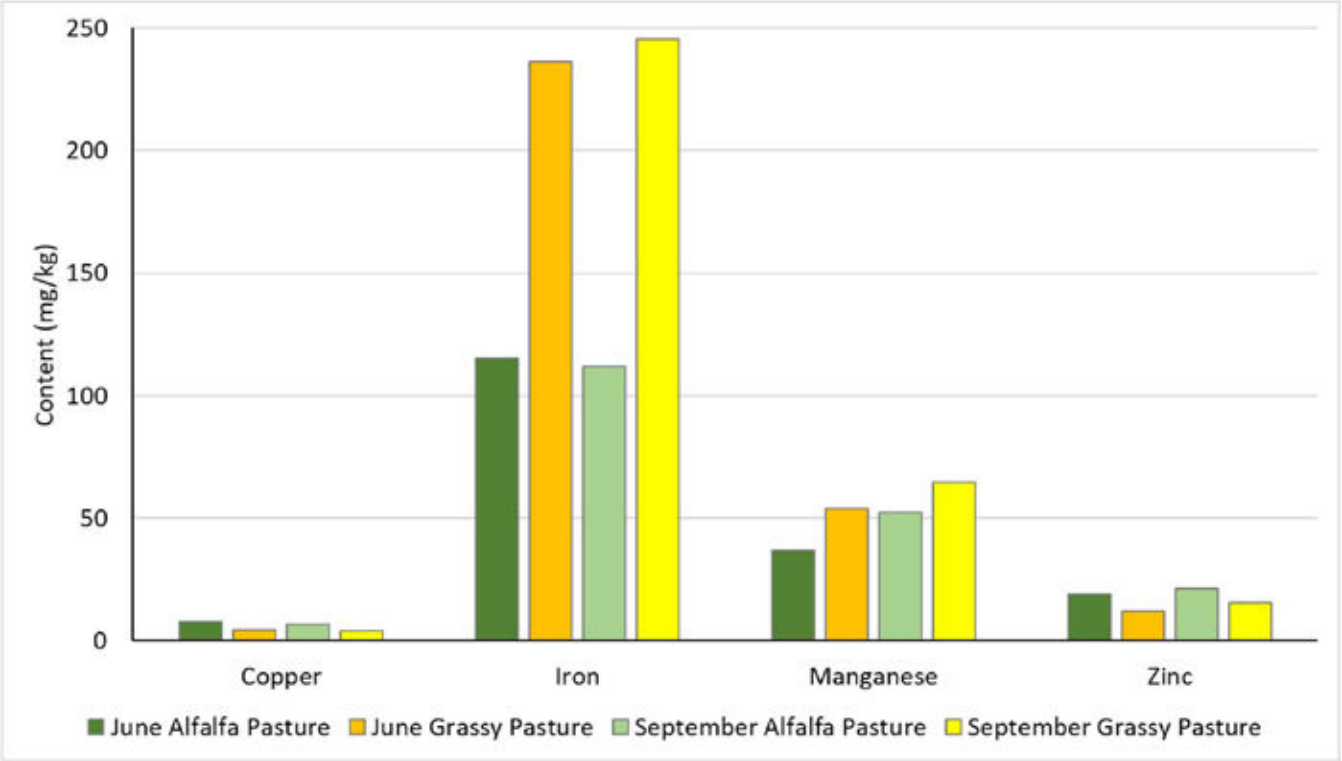

Figure 9. Micromineral content of alfalfa versus grassy pasture in Paddock C at First Street in late June and mid September of 2021. Eight subsamples are taken from among all alfalfa or non-alfalfa plots, and composited into one sample for the test.

Return on Investment

Labour rates, grazing rates, seed and fertilizer costs are based on the Province of Manitoba Costs of Production guides for 2021. Equipment use for this type of project was not clearly identified in the COP, so MBFI custom rates were used for seeding and fertilizer application. MBFI keeps track of labour and equipment hours, soil test cost, and fencing and water materials for their projects. From that data, reasonable adjustments are made to reflect how a livestock producer might approach a similar planting, and to omit any activities associated with data collection (other than soil testing recommended for fertilizer prescription).

The MBFI data was based on labour, equipment, and materials to drive to the site and spend time fencing and grazing all cells on the 8 acre project area. Thus, it was easiest to extrapolate costs to the whole 8 acre annual area of the project. These calculations are then divided by 8 to scale down to a per acre basis, then amortized over a 10-year period (expected minimum lifetime of a planting), before being compared with an annual benefit derived from productivity increase.

Cost and benefit categories, and the net, are presented in Table 4. Details are in Appendix A. On a 10-year basis, there was a net benefit to any of the practices. The increase in annual productivity makes it easily profitable, assuming good stand lifetime given the conservative approach that MBFI uses to graze the new alfalfa stands. The meagre profit for just fertilizing with phosphorus and sulfur is likely overstated for this pasture, as the productivity increase is unlikely to endure for the full 10 years.

The greatest cost was materials, for the fertility, seeding, mob grazing categories. Increasing fertilizer costs are going to reduce profitability for current and future plantings, but only marginally. For example double the 2021 fertilizer cost will only increase 10-year per acre amortized cost by $4, leaving per acre profitability still high.

Item	Do Nothing	Fertilize Only	Mob+Drill	Broadcast+Mob
Prep/Planning	0	112	184	184
Mob Grazing	0	0	1.331	1,331
Fertility	0	248	248	248
Planting	0	0	569	569
Grazing Loss	0	0	178	178
8-Acre Total	0	360	2,510	2,510
1-Acre Total	0	45	314	314
Annual (/10Yr) (A)	0	5	31	31
8-Acre Benefit	0	47	325	307
1-Acre Benefit (B)	0	12	82	76
1-Acre NET (B-A)	0	8	51	45

Table 4. Summary of costs and benefits (in $) for 3 approaches to improving legume content of pasture, and doing nothing, based on the Sod and Mob project at MBFI First Street Pasture.

Overall Summary

In summary, regardless of the method of planting alfalfa, by 2021, it has stabilized at a modest stem count, but has improved productivity and nutrient content. Return on investment is only slightly higher for the drill seeding versus broadcast and mob grazing, due to slightly less productivity in 2021. Simply fertilizing returns little profit, if any, and benefits may not last as long as for planting legumes.