

Pasture Renovation Through the Broadcasting of Birdsfoot Trefoil, Red Clover, and  
White Clover Seed

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**Abstract:**

Forage feeding of livestock on pasture has always been an important part of livestock agriculture. Pasture land often must be renovated to keep feed quality and forage production high. Many farmers also use pasture land to make use of otherwise unprofitable land, or to save on feed costs. Due to this, cost effective methods of pasture renovation are vital. This research, evaluated the ability of 3 different legume species [birdsfoot trefoil (*Lotus corniculatus*), red clover (*Trifolium pratense*), and white clover (*Trifolium repens*)] to establish when hand broadcast into naturalized pasture land at 2 different dates (one in spring, and the other in fall). The experiment was started in September of 2003 (at the first fall seeding), until this second year of data collection(Fall 2005). The cultivars of legumes seeded were AC Christie red clover, AC Langille birdsfoot trefoil, and Sonja white clover. Each of these legume species proved capable of establishing in the pasture. Red clover had the highest rate of establishment, followed by white clover, and lastly by birdsfoot trefoil(though differences between the legumes establishment rates were not significant). There was no significant effect on establishment with respect to the date of seeding. No significant interaction was seen between legume establishment and yield of either other grasses or broadleaf plants in the pasture. Legume establishment also had no significant effect on overall yield.

**Introduction:**

Forage feeding of livestock on pasture has been an important part of animal

agriculture, for as long as animal agriculture has been practiced. Pasture land provides an important food source for grazing livestock, and also makes use of land not capable of supporting other agricultural activities (Heath and Kaiser, 1985). Forages are the primary feed source for ruminant animals, making up 83.0% of beef cattle feed units, 91.1% of sheep and goat feed units, and 62.2% of dairy cattle feed units as of 1978 (Barnes 1985). For pasture land to keep producing adequate yields, however, the soil nutrient levels must be kept high enough to do so, especially nitrogen. Forages with higher protein concentrations are also considered to be of higher quality, and therefore having plants growing in the pasture which are high in protein is also desired in a healthy pasture. Legumes grown in the pasture help provide for both of these factors. Legumes are higher in protein than grasses, which generally are the dominant plants growing in pasture, and through a symbiotic relationship with rhizobia bacteria are capable of fixing atmospheric nitrogen. Established legumes not only fix enough nitrogen to supply their own needs, but also provide excess which may be utilized by other surrounding plants, which may eliminate the need for nitrogen fertilizer applications (Barnhart 2004, Heichel 1985).

Some reasons for which farmers will chose to graze their livestock on pasture are that legume-grass forage mixtures provide more protein than most stored grain feed, it may make use of otherwise unusable land they may have, and that grazing livestock will eliminate much of the cost associated with buying feed. About one third of the land area in the world is land which is generally not able to be cultivated, meaning that grazing is the the only way we are able to produce food from these lands (Heath 1985). Since many farmers are using pasture land to save money, it only makes sense that they would want to renovate their pasture inexpensively as well.

This experiment evaluates the effectiveness of birdsfoot trefoil (*Lotus corniculatus*), red clover (*Trifolium pratense*), and white clover (*Trifolium repens*) in

establishing in naturalized pasture land when broadcast as seed into the pasture. All three species were broadcast both in early spring and late fall to test the effect of date on legume establishment as well. Broadcasting of seed is by far the most inexpensive method for pasture renovation, however it also generally is less likely to be successful. In some cases, as low as ten percent of viable seed will establish when using this method (Charlton, 2005).

Birdsfoot trefoil has the advantage of being bloat resistant, and being adapted to a wide range of environments (McKenzie et. al. 2004). Birdsfoot trefoil however generally have lower seasonal yields than most other legume species, which is often attributed to its slow regrowth, and heavy reliance on photo-assimilates compared to stored nonstructural carbohydrates (McKenzie et. al. 2004). AC Langille as a cultivar is high yielding and has superior early spring growth (Papadopoulos 1997). Birdsfoot trefoil is the hardest of the three tested legumes to establish, however it tends to be very persistent once it is established.

White clover and red clover are the most important legumes of temperate pastures (Abberton 2005). Red clover brings considerable benefits in animal meat and milk quality, however it tends to be less persistent than white clover (Abberton 2005). Red clover generally only persists in pasture for two or three years, but is also the easiest of the tested legumes to establish. White clover is more persistent than red clover, and is considered the most important forage legume in Atlantic Canada (Forage and Corn Variety Evaluation Task Group, 2005). AC Christie red clover was bred to be a more persistent cultivar than was previously available (Martin, 1999). Sonja white clover is included in pastures because it shows superior forage production, and nitrogen fixation compared to wild varieties, and tends to be more persistent than larger leaved, more productive cultivars (Forage and Corn Variety Evaluation Task Group, 2005).

This is the second year of data collection and analysis on this experiment.

### **Materials and Methods:**

The experiment is being conducted on naturalized pasture fields located on Brookside Road, in Bible Hill, Nova Scotia. The study was done on the Organic Agriculture Association of Canada (OAAC) experimental fields. The soil type is a Woodville Sandy Loam, and has a pH varying from 5.7 in the east side of the fields, and 6.4 on the west.

The experiment originally was run as a 3-factor factorial experiment, the factors being animal species grazing, date seeded, and legume species. The experiment originally consisted of 6 blocks, each in a separate paddock. Each block contained seven 3 m x 10 m plots (one for each combination of date and legume species, and one control).

Experimental blocks were originally split between being grazed by sheep and being grazed by cattle (three cattle-grazed blocks, and three sheep-grazed blocks). The species grazing on the field however was not found to be significant in the first year (Comeau, 2004), and was discarded as a factor from the experiment in this year's data analysis. Both sheep and cattle also grazed on all fields in the 2005 season, making it pointless to attempt to analyze this factor.

There were two seeding dates: September 2<sup>nd</sup> 2003, and April 30<sup>th</sup> 2004. The legume seed was broadcast in September while the livestock were still grazing the fields, to reduce competition from other plants in the pasture during seedling emergence. The April broadcasting of seed was done just as the existing sward began to regrow, also to

ensure minimal competition during seedling growth.

Three legume species were broadcast: AC Langille birdsfoot trefoil, AC Christie red clover, and Sonja white clover. Birdsfoot trefoil was broadcast at a seeding rate of 9 kg/ha, red clover at 13.5 kg/ha, and white clover at 5.6 kg/ha. All seeds were inoculated with the appropriate rhizobia bacteria to form nitrogen fixing nodules with each legume species. All seed was broadcast by hand.

Plots were assigned to each treatment using randomized complete block design. Block and plot assignment can be seen in figure 1. The experiment was originally designed with six blocks, three for cattle and three for sheep, each containing all seven possible treatments. However, due to the exceptionally low pH of certain fields, and the need for some fields to be used in a larger scale drill sodding experiment using the same legume species, three of these blocks were dropped and not analyzed after the first plant density counting date. The blocks dropped from data collection and analysis were: cattle block 1, cattle block 3, and sheep block 3(Figure 1).

**Figure 1.** Experimental Design.

Cattle Block 1 (East)							Sheep Block 3 (East)							Cattle Block 3 (East)						
WC	BF	CN	RC	RC	BF	WC	RC	WC	CN	BF	WC	BF	RC	BF	WC	CN	RC	WC	BF	RC
F	S		F	S	F	S	F	S		F	F	S	S	F	S		F	F	S	S
<i>(No Treatments Applied)</i>							Sheep Block 2 (Center)							<i>(No Treatments Applied)</i>						
							BF	RC	CN	BF	WC	RC	WC							
Sheep Block 1 (West)							Cattle Block 2 (West)							<i>(No Treatments Applied)</i>						
WC	CN	BF	RC	BF	RC	WC	BF	RC	WC	WC	CN	BF	RC							

WC = White Clover, RC = Red Clover BF = Birdsfoot Trefoil F = Fall, S = Spring, CN = Control

Two main sets of data were collected for analysis during the summer of 2005. The data collected included the number of plants per m<sup>2</sup>, and yields. The number of plants was found by counting all of the legumes (seeded and other), within the area of a 0.25 m<sup>2</sup> quadrat. This was repeated three times per plot, and the density per m<sup>2</sup> calculated from this. Counts were done on May 21<sup>st</sup> and July 24<sup>th</sup> 2005. Yield measurements were done by clipping all plant material from approximately one inch height and above the ground within a 0.25 m<sup>2</sup> quadrat, and then the yield in kg/ha calculated. Plant clippings were dried at 55°C for 3 days before massing. Yield measurements were taken on June 10<sup>th</sup> and July 24<sup>th</sup> 2005. Only overall yield was measured on July 24<sup>th</sup>, and on June 10<sup>th</sup> plants were first separated into legume, grass and other plants then dried and massed separately.

Plant densities and yields were analyzed using Proc Mixed in the Statistical Analysis System (SAS Institute, Inc, Cary, NC, USA). Yields were analyzed as single factor data, with seven treatments (each legume species and date as a treatment, plus a control). Plant densities were analyzed as single factor tests with three treatments (each legume species as a treatment). Grass, broadleaf plant, and legume interactions with respect to yield were analyzed for Spearman correlation, also using SAS.

Along with these data sets, species composition was also determined. Species composition as determined by taking point quadrats of each plot. The point quadrats were taken by laying a meter stick in the plot, and determining the species which contacted the stick at every ten centimeters. This was repeated three times for each plot. The percent ground cover of each of the major species found were calculated based on this in each plot, and then those percentages averaged over all of the plots. Species composition was determined after establishment, on July 26<sup>th</sup> and 27<sup>th</sup>, 2005. Correlation between legume establishment and ground cover was tested against all other species' ground cover.

## **Results and Discussion:**

### Yield Measurements:

In the June 10<sup>th</sup> measurements, the mean yields were not significantly different (according to Tukey's test at  $P < 0.1$ ) either between treatments, or between the treatments and the control plots (See Table 1). The overall mean was 2735 kg/ha. These measurements were taken prior to animal grazing of the fields, and were therefore higher, and possibly a more fair assessment of the effect of the established legumes on the overall yield. Mean yields however, were not significantly different between treatments. This is likely do in part to the fact that establishment of legumes was quite low (see Table 3).

The July 24<sup>th</sup> measurements were done after the fields had been grazed by the livestock, and therefore were considerably lower. The control treatment again had no significant difference from any other treatment. The only significant difference between treatments was between spring-seeded red clover (highest yield) and fall-seeded birdsfoot trefoil (lowest yield). It's interesting to note that in the June measurements, even though differences were not significant, fall birdsfoot trefoil yield was actually the second highest. Considering this, I do not think it is an accurate assessment to claim that the significant difference between spring seeded red clover and birdsfoot trefoil, seen in the July 24<sup>th</sup> measurements, actually reflects a significant difference in these treatments overall.

**Table 1:** Effect of seeding date and legume species on yields at two dates.

<b>Date:</b>	<b>Species:</b>	<b>Mean Yield (kg/ha):</b>	
		<b>June 10, 2005</b>	<b>July 24, 2005</b>
Spring	Red Clover	3101 a	1409 a
Fall	Red Clover	2317 a	1351 ab
Spring	Birdsfoot Trefoil	2895 a	1308 ab
Fall	White Clover	2269 a	1277 ab
Control		2757 a	1168 ab
Spring	White Clover	2777 a	1081 ab
Fall	Birdsfoot Trefoil	3028 a	691 b

a-b Means with same letters indicate no significant difference based on Tukey's test at  $P < 0.1$

The forage samples harvested on June 10<sup>th</sup>, were separated according to plant types. Separate yields were measured for grasses, legumes, and other plant species. These numbers were compared largely to see if legume establishment was affecting overall yields, and if there was a correlation between other species and legume as well. Table 2 shows correlation significance between actual yields of legume, grass and other species, as well as percentages of each of these in the overall yield, and the overall yield. Legume yield and legume percentages did not have any significant correlation to any of the other factors. This may be due in part to how low the legume measurements were (making up between 0 and 16% of the yield, and averaging only 3.8%).

**Table 2:** Interaction between Yield, Grass, Legume, and Other Species based on dry weight

	<b>kg/ha Grass</b>	<b>kg/ha Legume</b>	<b>kg/ha Other</b>	<b>% Grass</b>	<b>% Legume</b>	<b>% Other</b>	<b>kg/ha Yield</b>
<b>kg/ha Grass</b>	1	ns	-0.47044	0.76999	ns	-0.74009	0.79727
<b>kg/ha Legume</b>		1	ns	ns	0.99023	ns	ns
<b>kg/ha Other</b>			1	-0.76364	ns	0.91818	ns
<b>% Grass</b>				1	ns	-0.85714	ns
<b>% Legume</b>					1	ns	ns
<b>% Other</b>						1	-0.42078
<b>kg/ha Yield</b>							1

Based on Spearman's test at  $P < 0.1$

Plant Counts:

Table 3 shows the mean plant densities counted on both counting dates. The May 21<sup>st</sup> counts were done prior to animal grazing this season, while July 24<sup>th</sup> counts were done afterwards. White clover was already present in the pasture prior to legume seeding, and was corrected for in these densities by subtracting the mean density of white clover in unseeded plots from the densities of the seeded ones. The subtracted means were calculated for each block separately, since each block had varying populations present.

**Table 3:** Effect of legume species on plant densities.

<b>Species:</b>	<b>Mean Density (Plants/m<sup>2</sup>):</b>	
	<b>May 21, 2005</b>	<b>July 24, 2005</b>
Birdsfoot Trefoil	1.3283 a	5.1167 a
White Clover	8.5223 ab	8.8933 a
Red Clover	12.0067 b	11.5717 a

a-b Means with same letters indicate no significant difference based on Tukey's test at P<0.1

In the first count, birdsfoot trefoil density was found to be significantly less than that of red clover, but neither were found to have a significant difference from white clover density. No differences between densities were found to be significant during the second count. The reason for this change in significance is the higher counted density of birdsfoot trefoil. The actual density of birdsfoot trefoil may have been higher in the second count, but the count may have been higher due to the fact that when the second count was done, the plants in the pasture were considerably shorter, making it easier to find the trefoil. This would not have affected the other legumes as dramatically as the trefoil, because the trefoil is a more erect plant, while the clovers both occupy wider areas per plant.

Another interesting point to note about trefoil establishment is that a trefoil was found to be growing in some plots, south of where they had been seeded as well. The most notable example of this was in sheep block 1 (see Figure 1), where seventeen trefoil plants were counted (22.7 plants/m<sup>2</sup>) in a red clover plot, one plot south of a trefoil plot where no plants were counted. This was actually the highest density of trefoil counted, even when compared to seeded plots. Birdsfoot trefoil is not naturalized to this area, and therefore we know that these plants grew as a result of the seeding. This situation may

have occurred by the natural spread of the trefoil seed, but was more likely an error in seeding, as the seed was all hand broadcast, and the prevailing wind in that area may be from the north. Seed may also have been moved by the grazing livestock before the seeds germinated. These trefoil plants, though they came from the seeding, were not included in the trefoil counts, as they did not occur in the trefoil plots. This means that the number of established birdsfoot trefoil plants, is actually occurring at a higher rate than indicated by the plant counts.

Plant counts done in May, on the blocks which were removed from analysis, were discarded from the May totals, to provide a fairer comparison between dates. The block with the poorest establishment on this first count was beef block 3. No white clover was present in this field, and grass was short, despite not yet being grazed. The only legume to establish on this ground was red clover. The area that was seeded with red clover was easily visible upon looking at the block, as it was growing possibly better than much of the grass even. This exemplifies the stronger ability of red clover to establish than the other two legumes.

#### Species Composition:

As is expected in naturalized pasture, there is quite a variety of species present. the most prominent species however are *Poa annua*, *Taraxacum*, *Alopecurus*, *Festuca*, and *Agrostis*, which account for over sixty percent of the ground cover. See Table 3 for the complete composition with respect to ground cover.

**Table 3:** Percent ground cover of species in pasture

<i>Species</i>	<i>Percent Ground Cover</i>
<i>Poa annua</i> (annual bluegrass)	23.5
<i>Taraxacum</i> (dandelion)	15.3
<i>Alopecurus</i> (meadow foxtail)	22.2
<i>Festuca</i> (fescue)	10.0
<i>Agrostis</i> (bentgrass)	12.1
<i>Phleum pratense</i> (timothy)	5.1
<i>Trifolium repens</i> (white clover)	4.1
<i>Ranunculus</i> (buttercup)	0.5
<i>Lotus corniculatus</i> (birdsfoot trefoil)	1.0
Vicia (vetch)	0.2
<i>Leontodon autumnalis</i> (fall dandelion)	1.8
<i>Trifolium pratense</i> (red clover)	1.6
<i>Elytrigia repens</i> (quackgrass)	1.9
<i>Stellaria graminea</i> (grass-leaved stitchwort)	0.8

This species composition data may prove relevant for futures studies, if comparing results of establishment in other naturalized pasture, to this experiment. Pastures of similar species compositions, may expect similar results, if other conditions are similar as well (such as pH and environmental factors). The only significant

interactions between ground cover of other species and seeded legume densities were:

Birdsfoot trefoil plant counts vs *Alopecurus*(-0.82) and vs birdsfoot trefoil(0.86)

Birdsfoot trefoil % ground cover vs. *Elytrigia repens*(0.73)

Red clover plant counts vs. *Festuca*(0.89)

Little correlation was seen between percent ground cover of pasture species and density of seeded legumes, and that which was seen, was only minor. Further research should be done to derive more certain conclusions with respect to this.

### **Conclusions:**

All three species of legume prove capable of establishing in a naturalized pasture, when inoculated with their appropriate symbiosis forming rhizobia bacteria, and broadcast into pasture. Red clover had the highest rate of establishment, followed by white clover, and lastly by birdsfoot trefoil, though none of these rates were significantly different. Red clover also proved to be capable of establishing in more acidic soil than the other two species.

Differences in seeding date had no significant affect on seeding date. There was also no significance to differences in seeding date or species, on overall yield, neither was there any significant difference in yields of seeded areas to those not seeded with legumes.

It is recommended that soil tests be done prior to seed broadcasting, so that conditions such as pH may be adjusted for optimum legume establishment and nitrogen fixation.

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