

Tillage Radish Project

The purpose of these trial plots is to determine the best use of radish to rejuvenate pasture. We wanted to look at how using tillage radish would compare with a conventional cultivation and reseeding practice. We are hoping that the radish will rejuvenate the pasture by releasing scavenged nutrients, drilling through hard pans to allow air and water to infiltrate and by increasing organic matter.

The sites chosen for the pasture rejuvenation project were both fields that had been down to pasture for over 20 years. The site on Hwy 22, NW-18-38-6-W5, is a typical lowland pasture in the County with peaty soil and hummocky topography. It is predominantly fescue and does not recover well after grazing. We will refer to this site as “Highway Radish”. The second site is on higher ground at the back end of the Bertagnolli home quarter, where the pasture has become root bound and produces very little growth, SW-18-38-06-W5. This site will be referred to as “Backend Radish”.

Backend radish Plot

We began the trials by marking off the plots and soil sampling the site on July 2nd 2015. Each plot is ½ acre. The soil test results showed that the nitrogen and phosphorous were seriously deficient and that the potassium and sulphur were marginal. The pH was 6.9 (neutral), the salinity showing to be good and the organic matter at 5.9 % which is slightly above average for our grey wooded soil. (see appendix 1).



Marking out the plots



Soil Sampling

On July 3rd plots 4 and 5 were sprayed out with glyphosate at the 2L per acre rate (960g a.i./acre).

The soil test fertilizer recommendations were very high compared with what we might expect to apply to a pasture. Knowing that in order for radish to get a good start it needs 40-60lbs of available N in the soil and also knowing the pasture grass seed would also be using nutrients as well as the existing pasture 80lbs N, 40lbs P and 30lbs K was applied on July 17th to the trial plots. Rain fell after the application delaying cultivations.

Backend radish Trials



PLOT 1	PLOT 2	PLOT 3	PLOT 4	PLOT 5
No Fertilizer	Fertilizer	Fertilizer	Fertilizer	Fertilizer
Radish Grass Seed	Radish	Radish Grass Seed	Glyphosate Radish And Grass seed	Glyphosate Cultivation And Grass seed
8lbs/acre grass seed 7lbs/acre radish	7lbs/acre radish	8lbs/acre grass seed 7lbs/acre radish	16lbs/acre grass seed 7lbs/acre radish	16lbs/acre seed

Cows and calves had been moved over to that site on April 24th directly after calving and moved off on June 10th to go to a different pasture. Due to the exhausted nature of the pasture there was very little re growth by the time of seeding.



Species present in the mix were:

Dandelion- 30% Alfalfa – 10%
 White clover -30% Plantain -10%
 Quack grass – 10%
 Timothy – 10%

Sample of Pasture Species in Tray

On July 22nd plot number #5 was ploughed, disced, and harrowed.



Seeding took place on July 24th 2015

Seeding of the radish into exhausted pasture was recommended at the 3-5lbs per acre rate at $\frac{1}{4}$ inch depth. Despite setting drill on the lowest setting and blocking off every other run it still seeded at 7lbs per acre. However due to dry conditions and hard soil surface we had trouble with the drill staying in the ground and so most of the seed was seeded at less than quarter of an inch and some was found on the surface. Soil to seed contact was therefore compromised. Tillage radish was seeded into plots 1, 2, 3, and 4.

The pasture grass seed was seeded at 8lb/acre on established pasture plots and 16lb/per acre on the glyphosated and cultivated plots. The seed used was donated by Seaborn Seeds and the mix is as follows:

Pasture Blend :

26% Orchard Grass

25% Red Clover

17% Alfalfa

9% Timothy

9% Annual Ryegrass

5% Creeping foxtail

5% Canada Blue grass

4% Alsike clover

Conditions for seeding were dry. Soil moisture was low and cause for concern. Radish seedlings emerged by July 31st but very few showing in the grass plots. A much better catch was found on the plot that was killed off first with glyphosate. However several small seedlings were observed in all plots and some seeds that were just germinating. By August 6th there was still minimum evidence of radish on plots 1-3 but the glyphosated plot was looking promising.



Radish seed on soil surface starting to sprout



Radishes emerging amongst the pasture plants in plots 1-3



Radishes emerging on Glyphosate plot, (plot 4)
August 6, 2015



August 25, 2015 radishes thriving in areas of
low competition.

Despite a good rain of just under an inch after seeding, by August 13th the tillage radish seedlings in the cotyledon stage looked like they were dying. Several days of record high temperatures in the low to mid 30's had taken their toll. Very few true leaves were found and the seedlings had turned yellow. Dry seeding conditions, too much competition, hot and dry conditions after emergence and limited soil to seed contact are the major concerns.

1 1/4 inches rain fell on August 14-15th- but came too late to save the radish seedlings on Plots 1- 3 . They had been burnt off by the extreme heat, dry soil and shallow seeding.

Plots 4 and 5 (no competition) however were looking promising. The pasture grass seed and tillage radish both showed good establishment but weeds were appearing in the cultivated plot.

By Fall 2015 plot 4 was showing the best results between the two plots due to good radish establishment, even grass catch and no visible weeds.



Plot 4 on October 15, 2015



Radish tops in Plot 4 grew between 2 and 3 feet tall



Roots were over 8 inches long in Plot 4





Roots were between 2 and 3 inches wide at the top in Plot 4

Cows were allowed to graze the plots at the end of October. The following April holes were visible in plot 4 where the tillage radish had grown and then rotted over the winter.



Holes left behind from the radish roots in plot 4 April, 2016

The cattle had grazed the plots right down in October 2015 and by the end of April 2016 were greening up with the pasture grass species.



Plot 4 April 30th 2016

The plots filled in during the Summer of 2016. Plot 4 was lush with new pasture species and looking to be a success. The annual weeds in plot 5 had mainly been choked out by the pasture grass but Canada Thistle was evident throughout the plot and will need to be sprayed.



End of August 2016

Plot 4 filling in with pasture species. Very few weeds were found.

Grass species had been successfully established in plot 5 in the Fall of 2015 along with a healthy weed population that had germinated after the cultivation. Weeds present were wild buck wheat, corn spurry, hemp nettle and Canada thistle.



Weeds and pasture grass species in plot 5 October 2015.



End of August 2016 Canada Thistle becoming well established in plot 5

Highway radish Project

The site picked for the demo site has been down to pasture for over a hundred years. It is quickly grazed down and is slow to recover. The soil is peaty and low and uneven. The pasture is exhausted and sod bound with fescue being the main grass that has taken over. The soil test results showed N and P to be very deficient and K marginal. The pH is alkaline at 7.9, the salinity good and organic matter 23%. This soil represents our typical muskeg pasture in the County. (appendix 2)

Clippings were taken from this site and using a quadrant the species present were estimated as follows:

Quadrant findings:

Creeping Red fescue	70%
Timothy	5%
Meadow Foxtail	5%
Kentucky Blue	5%
Dandelion/plantain	7.5%
White clover	7.5%



Hwy pasture clipping sample



Hwy Pasture

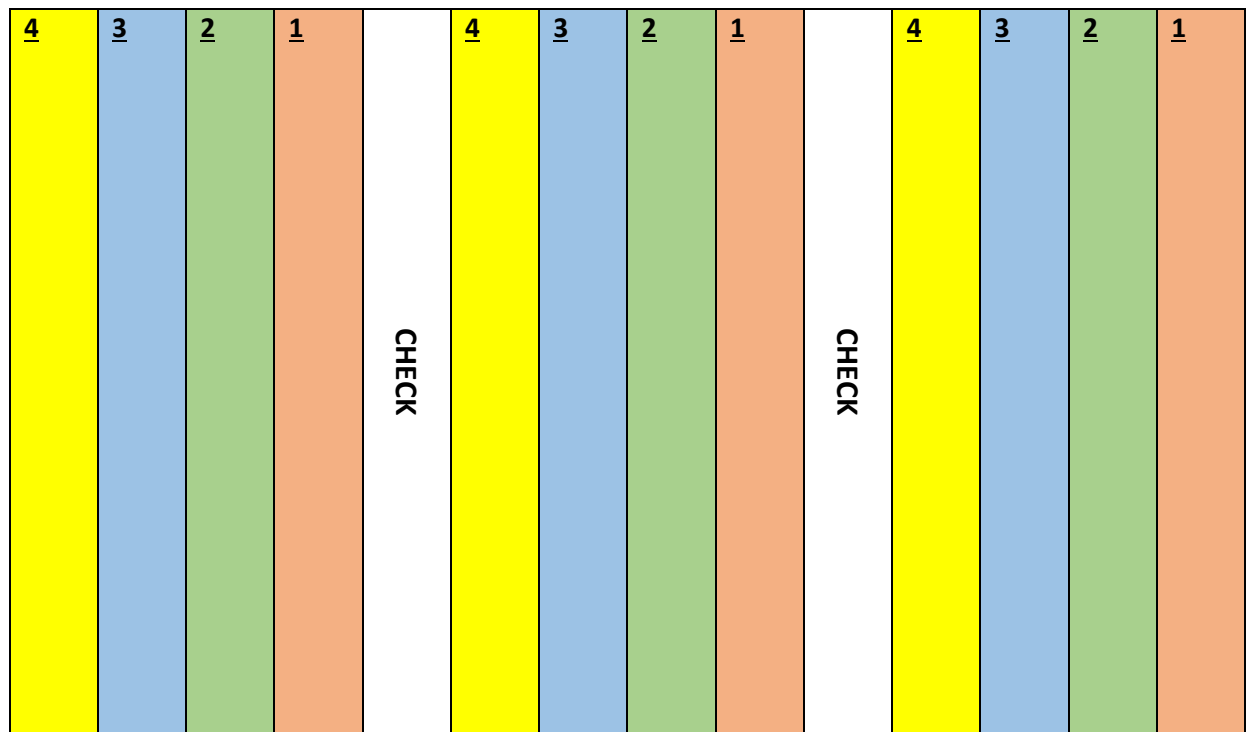
The site was mowed and fertilized before seeding. There was quite a bit of trash left on the surface after mowing which was cause for some concern.

Radishes were seeded North to South on entire site on July 26th. Due to concerns of the seeding depth on previous site the depth was lowered to $\frac{1}{2}$ to $\frac{3}{4}$ inch here.



The site was divided up into three sections and each section sub-divided into four plots. Plot 1 of each section was seeded to a lowland pasture mix also donated by Seaborn Seeds at a rate of 8lbs per acre in an East/West direction. The other three plots in each section will be used to show a frost seeding, no seeding and a following Spring seeding.

HIGHWAY RADISH



HIGHWAY 22

1. Orange- Grass seeded with radish (July 2015)
2. Green- Tillage radish only
3. Blue – Frost seed winter 2015
4. Yellow – Spring seed Spring 2016

Lowland pasture mix:

30% Creeping Foxtail

30% Annual Ryegrass

25% Jet Brand timothy

15% White clover

Radish seedlings had emerged by July 31st and by August 6th were looking stronger than the Backend radish trials. Seed to soil contact was better at this slighter deeper seeding and soil moisture in this peaty soil a probable advantage.



Weather during this time was warm and wet, perfect for germination and emergence. However during the critical time of growth following emergence we experienced hot and dry weather and the seedlings started to yellow. Emergence and vigour was very inconsistent.

11/4 inches of rain on August 14-15th-allowed the established seedlings to leaf out. However there was still concern that the badly yellowing seedlings may be dying.



Radish plants looking promising in areas of less competition.



Radish plants dying off in greater competition.

It was hoped that the late rain would save these radish seedlings. The soil to seed contact was better here due to increased seeding depth but it is believed that seeding even deeper would have allowed for better seedling vigour. By October very few tillage radish were apparent in the stand. Tops were small and roots did not amount to any size.



Tillage radish only survived in areas of less competition but overall were small in size.

The few radish plants that survived had small roots.





Due to fencing off the pasture for 3 months and the fertilizer application the fescue became very competitive and choked out most of the tillage radish. Radish only remained in bare patches and cow tracks.



Frost seeding of lowland mix occurred on November 2 2015 with day time temps between 0-5 degrees C and nighttime 0- -9 degrees C. Seed went on at 6 lbs an acre which was lighter than was planned.

On April 28th 2016 the spring seeding was carried out on the Highway site at a rate of 8lbs per acre. The soil conditions were dry.



Very little difference was noticed between plots. The tillage radish establishment had been a disappointment and it was hard to see any real comparisons between the three different times of seeding. It would seem that the mowing of the plot before seeding in July 2015 and the subsequent fertilizer application followed by resting the pasture for 3 months rejuvenated the fescue and established pasture plants but the tillage radish had no real affect.



Distinct improvement seen in the trial plot area is accredited to fertilizer and 3 month rest. Tillage radish were not successfully established here.

Soil Sampling

Soil samples were taken from all backend plots and 1 sample for the highway plot. Samples were taken on April 29th 2016.

Appendix 2 and 3

RESULTS

Highway plot

Most radishes had died out by the end of the September 2015 in areas of competition. A few radishes had put down roots of about 4- 5 inches in areas of lesser competition but not enough radishes survived to make an appreciable difference. Radish tops did not grow over 12 inches.

Very little difference was noticed in the hwy plot soil tests regarding nitrogen. Phosphorous and Potassium had increased but this could have been due to the fertilizer that was applied as the amount of radishes that grew successfully were not perceived to have been enough to have made a difference as the roots did not grow to any size. (Appendix 3).

Backend plots

Radishes died out early on in plots 1,2 and 3. The seeding of the pasture grass into the exhausted pasture did not establish well at all compared to plot 4. No significant difference was found in the soil tests due to the complete failure of the radishes. Plots 2 and 3 showed a marginal improvement in P over plot 1 presumably due to the fertilizer. Overall these three plots were very disappointing and even despite fertilizing and reseeding did not show any signs of rejuvenation. (Appendix 4, 5 and 6) The low organic matter and root bound state of the exhausted pasture did not allow for successful reseeding.

The radishes in plot 4 where the competition had been removed by glyphosate grew well. The roots measured over 8 inches long and averaged 2-3 inches wide at the root top. Foliage tops were measured over 24 inches and establishment was consistent. Pasture grass establishment was also consistent and healthy. By the end of October, 2015 plot number 4 was looking very promising with healthy radish plants and well established pasture species. By August 2016 plot 4 was looking healthy and lush with a diverse establishment of pasture species and good yield.

Plot 4 showed a marked increase in N from 8lbs/acre to 50lbs/acre and a decent increase in phosphorous from 14lbs to 37lbs. Potassium level was the highest in plot 4 at 581lbs/acre pushing it well into the optimum range. Plot 4 showed organic matter of 5.9% compared with the other 4 plots showing 4.9%. (Appendix 7).

Plot 5 which had been conventionally cultivated and no radishes planted showed a similar increase in N but no real increase in phosphorous or potassium. (Appendix 8) Pasture grass species established well in plot 5 but so too did the weeds. There were significantly more weeds in the cultivated plot 5 than in plot 4, especially Canada thistle and bindweed, hemp nettle and corn spurry.

Conclusions

The main conclusion to be drawn from this project was that tillage radish does not compete well in established sod. Consistently, tillage radish seed germinated but died out at the cotyledon stage when competition was present. Tillage radish proved much more successful where existing sod had been sprayed out or the soil cultivated as in previous trials. Soil to seed contact is very important and it would appear that tillage radish can be seeded as deep as 1 inch into sod and this should be recommended especially in dry years.

Tillage radish do not do well in dry, hot conditions, preferring cool moist conditions which would be more typical for this area on a normal year. Once emerged hot dry conditions can be very detrimental.

As far as pasture grass establishment was concerned it was found that the plot that had been conventionally cultivated had weeds establishing quite quickly that competed with pasture grass seedlings. The plot which had been sprayed and used only the radish as tillage had barely any weeds at all and so allowed for a more consistent pasture seed establishment.

Overall Plot 4 which had been sprayed with glyphosate, and direct drilled to radish and pasture grass showed the best results of all the trial plots. Grass establishment was found to be the most consistent and healthy, weeds were kept to a minimum, soil was enhanced nutritionally and soil texture and organic matter improved.

Using a combination of glyphosate and tillage radish could be a good way to work up pastures and reseed without using tillage equipment. This method reduces weed competition while allowing for an even pasture stand. The radishes can establish well when the competition is removed and are able to pull up nutrients, aerate soil, break up roots and add organic matter after breaking down.

Future trials may include rolling the area after seeding or allowing the cows to tramp down the pasture directly after seeding to “punch” the seed into the pasture to enhance soil to seed contact. It would also be beneficial to do more trials after burning off the existing pasture with glyphosate and comparing different seeding rates, seeding depth and timing of seeding for both the tillage radish seed and pasture grass seed.

Links to other Tillage Radish Research

1. Tillage Radish Trials by West Central Forage Association

www.westcentralforage.com/projects/tillage-radish

www.westcentralforage.com/projects/forage-radish-variety-trial.aspx

2. Hard Pan's New Foe – Western Producer

<http://www.producer.com/2010/11/hardpans-new-foe-the-radish/>

3. Tillage Radish The Next Big Thing

http://peacecountrybeef.ca/wp-content/uploads/2013/02/FF_v7-81october-tillageradishesandnitrates.pdf

4. Tillage radish - A new Option for Renewed Soil Health

<http://www.topcropmanager.com/tillage/tillage-radishes-%E2%80%93-a-new-option-for-improved-soil-health-14543>

Appendix 1 Backend Soil sample July 2015

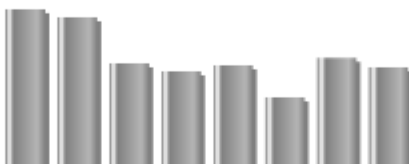
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Farm Soil Analysis

Bill To:	Clearwater County	Grower Name:		Lot Number:	1080160
Report To:	Clearwater County	Client's Sample Id:		Report Number:	2024110
	Box 550	Field Id:	Radish Backend	Date Received:	Jul 07, 2015
	4340-47 Avenue	Acres:	5	Disposal Date:	Aug 06, 2015
	Rocky Mountain House,	Legal Location:		Report Date:	Jul 08, 2015
	T4T 1A4	Last Crop:	Pasture - Grass	Arrival Condition:	
Agreement:	99360				

Nutrient analysis (ppm)														Soil Quality			
Depth	N*	P	K	S**	Ca	Mg	Fe	Cu	Zn	B	Mn	Cl	BiCerbP	pH	EC(dS/m)	OM(%)	Sample#
0" - 6"	<2	7	203	5	2590	258	93	0.8	2	0.6	10.9	8.5		6.9	0.31	5.9	5132742
6" - 12"	<2	<5	154	4	2640	242	80	0.6	1	0.4	9.3	6.6		7.1	0.44	4.3	5132743
Excess														Alkaline	Very Toxic	High	
Optimum														Neutral	Toxic	Normal	
Marginal														Acidic	Caution	Low	
Deficient														Very Acidic	Good	Very Low	
Total lbs/acre	8	14	406	17	Texture n/a			Hand Texture n/a			BS 100 %			Ca 83.1 %	Mg 13.6 %	Na <0.8 %	K 3.3 %
Estimated lbs/acre	10	14	406	20	Sand n/a			Silt n/a			TEC 15.6 meq/100g			Na <30 ppm			
					Ammonium n/a			Lime 0 T/ac			Buffer pH Not Required			Est. N Release n/a			
					C:N Ratio n/a												

*Nitrate-N **Sulfate-S n/a = not analysed

RECOMMENDATIONS FOR BALANCED CROP NUTRITION

Macro-nutrients	Pasture - Grass					Radish				
	Yield	N	P ₂ O ₅	K ₂ O	S	Yield	N	P ₂ O ₅	K ₂ O	S
Growing Condition	T/ac	To be added (lbs/acre)				To be added (lbs/acre)				
Excellent	5.2	114	46	0	18	89	169	51	9	
Average	3.4	85	37	0	11	86	164	40	8	
Your Goal	0.0									
Removal Rate (Seed/Total)	5.2	0 / 195	0 / 57	0 / 247	0 / 24					
Micro-nutrients	Iron	Copper	Zinc	Boron	Manganese	Iron	Copper	Zinc	Boron	Manganese
To be added (lbs/ac)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

The ideal pH range is 6.0 to 7.5

Comments:

Recommendations are based on general research consensus. They should not replace responsible judgement.

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Appendix 2 Hwy soil sample July 2015

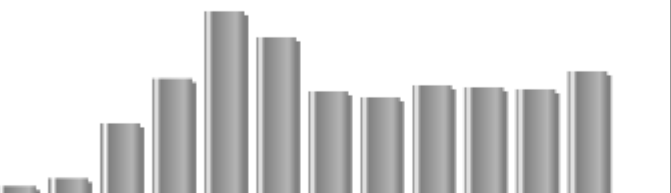
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Farm Soil Analysis

Bill To:	Clearwater County	Grower Name:		Lot Number:	1080160
Report To:	Clearwater County	Client's Sample Id:		Report Number:	2024111
	Box 550	Field Id:	Radish Highway Pasture	Date Received:	Jul 07, 2015
	4340-47 Avenue	Acres:	10	Disposal Date:	Aug 06, 2015
	Rocky Mountain House,	Legal Location:		Report Date:	Jul 08, 2015
	T4T 1A4	Last Crop:	Pasture - Grass	Arrival Condition:	
Agreement:	99360				

Nutrient analysis (ppm)														Soil Quality			
Depth	N*	P	K	S**	Ca	Mg	Fe	Cu	Zn	B	Mn	Cl	BiCwbP	pH	EC(dS/m)	OM(%)	Sample#
0" - 6"	3	<5	108	13	7290	875	97	0.8	5.0	1.2	7.9	53.0		7.9	0.71	23.7	5132744
6" - 12"	2	<5	118	6	6960	867	78	0.9	3.2	0.7	7.2	51.0		7.9	0.69	14.1	5132745
Excess														Alkaline	Very Toxic	High	
Optimum														Neutral	Toxic	Normal	
Marginal														Acidic	Caution	Low	
Deficient														Very Acidic	Good	Very Low	
Total lbs/acre	11	10	216	39	Texture n/a			Hand Texture n/a			BS 100 %			Ca 82.4 %	Mg 16.3 %	Na 0.6 %	K 0.6 %
Estimated lbs/acre	14	10	216	47	Sand n/a			Silt n/a			Clay n/a			TEC 44.1 meq/100g	Na 60 ppm		
	Ammonium n/a			Lime 0 T/ac			Buffer pH Not Required			Est. N Release n/a			C:N Ratio n/a				

*Nitrate-N **Sulfate-S n/a = not analysed

RECOMMENDATIONS FOR BALANCED CROP NUTRITION

Macro-nutrients	Pasture - Grass					Radish				
	Yield	N	P ₂ O ₅	K ₂ O	S	Yield	N	P ₂ O ₅	K ₂ O	S
Growing Condition	T/ac	To be added (lbs/acre)				To be added (lbs/acre)				
Excellent	5.1	108	48	55	0	86	176	175	0	0
Average	3.4	79	39	40	0	83	171	165	0	0
Your Goal	0.0									
Removal Rate (Seed/Total)	5.1	0 / 194	0 / 57	0 / 245	0 / 24					
Micro-nutrients										
	Iron	Copper	Zinc	Boron	Manganese	Iron	Copper	Zinc	Boron	Manganese
To be added (lbs/ac)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

The ideal pH range is 6.0 to 7.5

Comments:

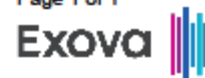
Recommendations are based on general research consensus. They should not replace responsible judgement.

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Appendix 3. Hwy soil sample April 2016

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Farm Soil Analysis

Bill To:	Clearwater County	Grower Name:	Highway Field	Lot Number:	1134856
Report To:	Clearwater County	Client's Sample Id:		Report Number:	2099746
	Box 550	Field Id:	HWY Pasture Plot 1	Date Received:	Apr 29, 2016
	4340-47 Avenue	Acres:	1	Disposal Date:	May 29, 2016
	Rocky Mountain House,	Legal Location:		Report Date:	May 02, 2016
	T4T 1A4	Last Crop:	Pasture - Grass	Arrival Condition:	
Agreement:	99360				

Nutrient analysis (ppm)														Soil Quality			
Depth	N*	P	K	S**	Ca	Mg	Fe	Cu	Zn	B	Mn	Cl	BiCarbP	pH	EC(dS/m)	OM(%)	Sample#
0" - 6"	6	18	195	10	7760	996								7.7	0.92	32.7	5399815
Excess														Alkaline	Extreme	High	
Optimum														+	Neutral	Very High	Normal
Marginal														Acidic	High	Low	
Deficient														Very Acidic	Good	Very Low	
Total lbs/acre	11	36	391	21	Texture n/a				Sand n/a				Hand Texture n/a	BS 100 %			
					Silt n/a				Clay n/a					Ca 81.3 %	Mg 17.2 %	Na 0.4 %	K 1.1 %
Estimated lbs/acre	23	36	391	43	Ammonium n/a				Lime n/a				Buffer pH	Not Required			
					Est. N Release n/a				C:N Ratio n/a								

*Nitrate-N **Sulfate-S n/a = not analysed

RECOMMENDATIONS FOR BALANCED CROP NUTRITION

Pasture - Grass					
Macro-nutrients	Yield	N	P ₂ O ₅	K ₂ O	S
Growing Condition	T/ac	To be added (lbs/acre)			
Excellent	5.2	110	36	35	0
Average	3.5	81	26	22	0
Your Goal	0.0				
Removal Rate (Seed/Total)	5.2	0 / 197	0 / 58	0 / 249	0 / 24
Micro-nutrients	Iron	Copper	Zinc	Boron	Manganese
To be added (lbs/ac)	n/a	n/a	n/a	n/a	n/a

Comments:

Recommendations are based on general research consensus. They should not replace responsible judgement.

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Appendix 4 Backend plot 1 April 2016

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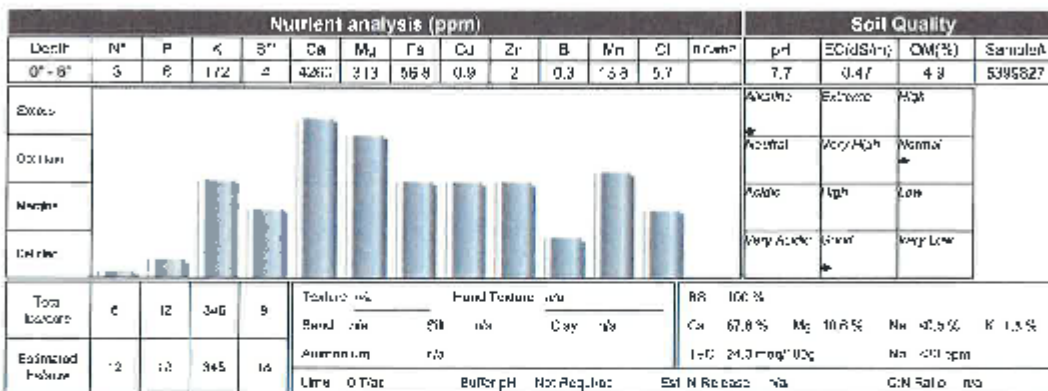
1-800-833-3333
1-800-833-3333
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1-800-833-3333

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Farm Soil Analysis

BL Loc: Clearwater County	Grower Name: County	Lot Number: 1134685
Report To: Clearwater County	Client's Sample Id:	Report Number: 2095769
Box 550	Field In: Barkand Pul'	Date Received: Apr 29, 2016
434C-17 Avenue	Acres: 1	Discard Date: May 29, 2016
Rocky Mountain House,	Legal Location:	Report Date: May 02, 2016
T4T - A1	Last Group:	Arrival Condition:
Agreement: 55030		



RECOMMENDATIONS FOR BALANCED CROP NUTRITION

Fertilizer Nutrients	Pasture Grass				
	Yield	N	P2O5	K2O	S
Growing Condition	T/aa	To be added (lb/acre)			
Excellent	5.2	11'	47	16	17
Average	3.4	8'	38	22	11
Yield Goal	0.0				
Removal Rate (Soil/Total)	5.2	0.7/195	11.7/57	1.7/246	0.7/24
Micro-nutrients	Iron	Copper	Zinc	Manganese	
To be added (lb/acre)	0.3	0.0	0.0	0.1	0.0

Parts of the feed may be below deficient

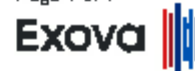
Comments:

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Appendix 5 Backend plot 2 Soil Sample April 2016


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Farm Soil Analysis

Bill To: Clearwater County	Grower Name: Backend Plot 2	Lot Number: 1054855
Report To: Clearwater County	Client's Sample ID:	Report Number: 2009780
Box 550	Field ID: Backend Plot 2	Date Received: Apr 29, 2016
4340 47 Avenue	Acres: 1	Discard Date: May 29, 2018
Hwy 1 Mile N. of H. 50A	Legal Location:	Report Date: May 02, 2016
T4T 1A4	Last Crop:	Arrival Conditions:
Agreement: 895601		

Nutrient analysis (ppm)														Soil Quality			
Depth	N*	P	K	S**	Ca	Mg	Fe	Cu	Zn	B	Mn	Cl	EC (cm)	pH	FC(15cm)	OM(%)	Sample#
0" - 6"	3	8	174	4	3620	297	83.1	0.9	7	0.3	20.3	6.6		7.6	0.63	4.9	5359329
Location														Alkaline	Extreme	High	
Optimum														Neutral	Very High	Normal	
Marginal														Acidic	High	Low	
Deficient														Very Acidic	Good	Very Low	
Total Nitrogen	5	18	340	9	Texture: s/s			Hard Texture: n/s			ES: 100 %						
					Sand: n/s			Silt: n/s			Clay: n/s						
Labored Estimate	10	10	308	13	Ammonium: n/s						Ca: 56.9 %			Mg: 11.3 %		Na: <0.3 %	K: 2.1 %
					Line: C Time			Buffer pH: Not Required			Est. N Release: n/s			C/N Ratio: n/s			
											TTC: 21.1 mg/100g			Na: <30 ppm			

Microbial: n/s, Sulfate-S: n/s, n/s = not analyzed

RECOMMENDATIONS FOR BALANCED CROP NUTRITION

Macro-nutrients	Pasture - Grass				
	Yield	N	P2O5	K2O	S
Growing Condition	7.8t	To be added (lbs/acre)			
Excellent	8.2	114	44	35	18
Average	3.4	85	35	22	11
Your Goal	0.0				
Removal Rate (Seed/total)	5.2	0.7/105	0.7/57	0.7/247	0.7/24
Micro-nutrients	Iron	Copper	Zinc	Manganese	Molybdenum
To be added (lbs/acre)	3.0	11.0	0.0	2.0	3.0

Add Boron only a test strip.

Comments:

Recommendations are based on general research consensus. They should not replace reasonable judgement.

Exova is not responsible for any damage or loss of crops or other property.

Appendix 6. Backend Plot 3 soil sample April 2016

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Farm Soil Analysis

Bill To: Clearwater County Report To: Clearwater County Box 160 4340-47 Avenue Rocky Mountain House, T4T 1A4 Agreement: 99080	Grower Name: Backend Plot 3 Client's Sample Id: Field Id: Backend Plot 3 Acres: 1 Legal Location: Last Crop:	Lot Number: 1134865 Account Number: 2099781 Date Received: Apr 29, 2016 Disposal Date: May 28, 2016 Report Date: May 02, 2016 Arrival Condition:
--	---	---

Nutrient analysis (ppm)														Soil Quality			
Depth	N*	P	K	S**	Ca	Mg	Fa	Cu	Zn	B	Mn	Cl	Moisture	pH	EC(dS/m)	OM(%)	Sample#
0" - 8"	3	10	244	4	3850	295	51.7	3.8	2	0.4	14.4	5.7		7.6	0.50	4.9	039583C
Exotic														Normal	Extreme	High	
Optimal														Normal	Very High	Normal	
Wetland														Acidic	High	Low	
Salinity														Very Acidic	Good	Very Low	
Total Solids	5	19	<88	5	Texture n/a				Sand Texture n/a				ES	100 %			
					Sand n/a				Silt n/a				Ca	88.4 %			
									Clay n/a				Mg	10.8 %			
Ammonium Nitrate	11	19	<88	18	Ammonium n/a								TCC	22.5 mg/100g			
Lime	0 T/acre				Buffer 0				Not Required				Est. N Release	n/a			
													C:N Ratio	n/a			

*N rate N **Sulfate S n/a = not analyzed

RECOMMENDATIONS FOR BALANCED CROP NUTRITION

Macronutrients	Pasture - Grass				
	Yield	N	P2O5	K2O	S
Growing Condition	T/acre	To be added (lb/acre)			
Excellent	5.2	1.4	.04	0	18
Average	3.4	.84	.35	0	11
Your Goal	0.9				
Removal Rate (Seed/Total)	5.2	0.1185	0.157	0.1247	0.124
Micro-nutrients	Iron	Copper	Zinc	Boron	Manganese
To be added (lb/acre)	0.0	0.01	0.01	0.01	0.0

Parts of the field may be Boron deficient.

Comments:

Recommendations are based on general research consensus. They should not replace responsible judgement.

Terms and Conditions: www.exova.com/about/terms-and-conditions

Appendix 7. Backend Plot 4 Soil Sample April 2016

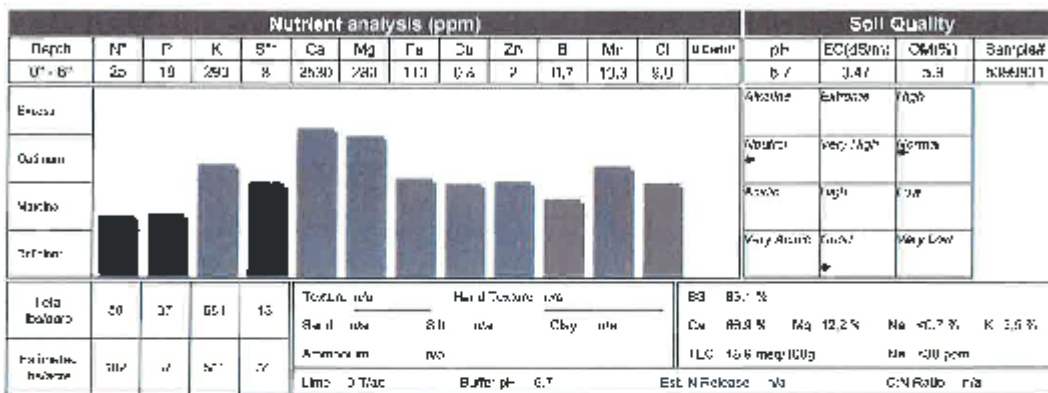
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Farm Soil Analysis

Bill To:	Clearwater County	Grower Name:	Backend	Lot Number:	1134665
Report To:	Clearwater County	Client's Sample Id:		Report Number:	2099762
	Box 563	Field Id:	Backend Plot 4	Date Received:	Apr 20, 2016
	4340-47 Avenue	Acres:		Dispatch Date:	May 29, 2016
	Rocky Mountain House	Legal Location:		Receipt Date:	May 31, 2016
	T1T 1A4	Last Crop:		Arrival Condition:	
Agreement:	99260				



*Nitrogen **Sulfate †Urea

RECOMMENDATIONS FOR BALANCED CROP NUTRITION

Macro-nutrients	Yield	Pesticide - Grass			
		N	P2O5	K2O	S
Optimal Condition	T/ha	To be added (lbs/acre)			
Excellent	5.2	40	30	0	0
Average	3.5	11	26	0	0
Your Soil	0.0				
Removal Rate (Seedling)	5.2	0.157	0.157	0.1243	0.124
Micro-nutrients	Iron	Copper	Zinc	Boron	Manganese
To be added (lbs/ha)	0.0	0.0	0.0	0.0	0.0

Comments:

Recommendations are based on general research consensus. They should not replace responsible judgement.
To find out more, see www.exova.com/soil-analysis

Appendix 8. Backend Plot 5 Soil Sample April 2016

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Farm Soil Analysis

Bill To:	Clearwater County	Cropper Name:	Backend	Lot Number:	1134895
Report To:	Clearwater County	Client's Sample ID:		Report Number:	2096753
	Box 550	Field ID:	Backend Plot 5	Date Received:	Apr 29, 2016
	4340-47 Avenue	Acres:	1	Disposal Date:	May 29, 2016
	Rocky Mountain House	Legal Location:		Report Date:	May 02, 2016
	T4T 1A4	Last Crop:		Arrival Condition:	
Agreement:	99360				

Nutrient analysis (ppm)														Soil Quality			
Depth	N*	P	K	S**	Ca	Mg	Fe	Cu	Zn	B	Mn	Cl	NO ₃ -N***	pH	EC(dS/m)	OM(%)	Sample#
0" - 6"	25	9	484	7	2210	251	133	3.8	2.0	0.5	46.0	0.0		8.3	1.30	4.9	E399032
Texture														Alkaline	Extreme	High	
Odour														Neutral	Very High	Neutral	
Moisture														Alkalic	High	Low	
Condition														Very Alkalic	Good	Very Low	
Total Nitrogen	51	19	367	13	Total Ca n/a			Total Text. n/a			R5 60.0 %						
Exchangeable Nitrogen	104	13	357	27	Sand n/a			Silt n/a			Clay n/a			Ca 59.1 % Mg 10.5 % Na <0.7 % K 2.4 %			
					Ammonium n/a						TES 10.7 mg/100g			Na <30 ppm			
					Urea 1.0 %			Buffer pH 8.4			Est. N Release n/a			C:N Ratio n/a			

*N-test-N **S-test-S ***N-test-N

RECOMMENDATIONS FOR BALANCED CROP NUTRITION

Macronutrients	Pasture - Grass				
	Yield	N	P2O5	K2O	S
Cowling Condition	Total	To be added (lb/acre)			
Excellent	5.2	35	42	55	18
Average	3.4	8	35	22	11
Yield Goal	0.0				
Retention Rate (Seed/Total)	5.2	0.198	0.157	0.1246	0.124
Macronutrients	Iron	Copper	Zinc	Boron	Manganese
To be added (lb/acre)	0.0	0.0	0.0	0.0	0.0

Parts of the field may be Boron deficient.

Comments:

Recommendations are based on general research consensus. They should not replace responsible judgement.

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