Evaluation of Raw and Processed Humalite on Soil Health Indicators in Two Agro-ecosystems (Annual and Land-Remediation)

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Acknowledgement: This study was funded by Westmoreland Mining Holdings LLC

Abstract

Two studies to evaluate the benefits on soil health and crop performances of different levels of Humic materials from Raw Humalite (RH) and Processed Humalite (PH) were conducted on a sandy loam (Annual Crop; AC) and Loam (Land-Remediation-Oats; LR) in east central Alberta. The PH used were Canadian Humalite (P-CH), Humi(K), and BlackEarth. Same treatments were applied at seeding for LR-Oats and post seeding for AC-Canola with their recommended soil NPK base on sol fertility status. Treatments were: Raw Humalite (RH) and Raw Humalite Sifted (RHS) at 100 and 250 lb/A each; PH from Canadian Humalite (PH-CH) and PH from Black Earth (PH-BE) at 250 lb/A; PH from Humi(K) 2 and 4 lb/A and the control (no Humalite). Treatments were replicated 4 times in a complete randomized block design for statistical evaluation. A soil health benchmark was done in both sites for monitoring treatments responses over time. Both sites presented poor soil aggregate stability with a compacted soil in the annual cropping system. Biological assessments showed that both soils are bacteria dominant, with a higher level in the remediation side. Active Carbon levels were at low levels, decreasing by depth in the annual system but increasing in the remediation site. In general, both site soils can be considered with low biological activities and low diversities at the rooting zone. Differences in the parameters evaluated for the Annual cropping system (Canola yield) and the Land-Remediation site (Oats: Biomass, crude protein content and feed analysis) from the treatments applied were not statistically significant. The lack of statistical response might be attributed to the high variability observed within treatments. The canola yields were within the average yield range for the area (27-30 bu/A) with the exception being the highest yield of 38 bu/A for the RH at 100 lb/A. On the contrary, oat biomass production was lower than a local oat silage study which yielded an average of 4000 lb/A in 2020. The highest biomass for oats in the study was 3651 lb/A for the 2 lb/A for Humi(K). Applications of these materials, however, show a trend (although not statistically significant) of increasing canola yield up to 9 bu/A and up to 1100 lb/A of oats biomass when they were compared with the control. Feed analyses of the oat biomass showed some of the nutrients were not in balance for complete cattle rations which could be attributed to the unbalanced nutrients in the soil (low P, high N, K, Mg). Biomass nutrient levels were low for P, Ca and Cu, high for K, Mg, Fe and Mn while crude protein and Zn were in the desired levels. It is important to continue to monitor these impacts overtime as they can be influenced by soil parameters.

Objective: To evaluate the benefit to soil health constraints and crop yield from various humalite products on a reclaimed soil and within an annual cropping system.

Material and methods

These studies were located at SE 25-29-13-W4 (Annual Crop; AC-Canola) and NW 33-30-11-W4 Land Remediation; LR-Oats) near Hanna, Alberta. Canola (Liberty 1234, at 4 lb/A, 6-8 plants/square foot) was seeded into a pea stubble and oats (CDC Baler, 75 lb/A) in a recently reclaimed topsoil. Table 1 contains a summary of the treatments which were replicated 4 times in a complete randomized block design for statistical analysis. All treatments were applied in plot sizes of 67 m^2. All plots received a base soil nutrient recommendation of 150 lb/A of 26-18-5-3. A soil health benchmark analysis was done at both sites prior to seeding for monitoring treatment responses over time (see reports in Annex A-AC-Canola and Annex B-LR-Oats). Treatments were broadcasted at both sites, at seeding at LR-Oats and at the rosette stage at the AC-Canola. Table 2 shows Hanna area precipitation (in inches) for 2020. Oats was seeded (June 24) using CARA's Henderson 500 small plot drill and the AC-Canola site was seeded with a field size air drill (May 15). The canola was harvested using a Wintersteiger combine on September 18. The LR-oat biomass was cut September 23 using a flail type forage cutter. Table 3 shows the canola yield, bushel weight and TKW (thousand kernel weight). Table 4 and 5 shows the oat biomass yield and feed quality, micro and macro nutrients. All data were analyzed for statistical significance by using one-way ANOVA and LSD of the mean by Minitab 17.

Table 1. **Humic Materials and Treatment Descriptions**

Treat	Treatment Descriptions	
TRT-1	NPK-Control*	NO Humic material only NPK
TRT-2	RH100	Raw Humalite 100 lb/A
TRT-3	RH250	Raw Humalite 250 lb/A
TRT-4	RH100Sift	Raw Humalite sifted to <5 mm particle size 100 lb/A
TRT-5	RH250Sift	Raw Humalite sifted to <5 mm mesh 250 lb/A
TRT-6	Humi(K)2	Processed Humalite brand Humi(k) 2 lb/A
TRT-7	Humi(K)4	Processed Humalite brand Humi(k) 4 lb/A
TRT-8	PH-CH250	Processed Humalite brand Canadian Humalite 250 lb/A
TRT-9	PH-BE250	Processed Humalite brand Black Earth 250 lb/A

*All treatments received the same NPK recommended fertilizer

Table 2. **Precipitation**

Month	Inch
May	2.5
June	4.7
July	2.4
Aug	1.9
Total	11.4

Results and Discussion:
Soil health benchmarks for two sites showed physical, chemical and biological constraints. Both sites presented poor soil aggregate stability. Active Carbon levels were low, decreasing by depth in the annual system but increasing in the remediation site. The remediation site had a higher level of total carbon content which might be characteristic of this soil from within the mine site. High C:N ratios (as documented for this site) can immobilize N during high microbial activity. In general, evaluation of soils at both sites show low biological activities and low diversities at the rooting zone. The soil microbial respiration (Annex A-AC-Canola Biophysical & Others), 0.28, 0.25, 0.17 mg CO_2/g soil at depths of 0-3, 3-6, 6-12 inches respectively, were low when compared with more active soils (0.6 $\pm$ 0.3 mg CO_2/g soil) is corroborated with the low biological diversity reported in the Soil Food Web assessment (Annex A-AC-CANOLA-SFW). In both sites' fungal biomass, protozoa (count and diversity) and nematodes (counts) decrease by depth while bacteria biomass increases. This is an indication of these soils being bacteria dominant. It was also observed that there were extremely low nematode counts (less than 1 nematode /g soil) in both sites (Annex A-AC-CANOLA-SFW and Annex B-LR-Oats-SFW). Future soil evaluations of these sites at 0-3 inches will allow us to see the treatment effects on soil biology.

There were also physical and chemical constraints in both sites (Annex A-AC-CANOLA-Biophysical & Others and Annex B-LR-Oats-Biophysical & Others). Soil wet aggregates were less than 21%, which is an indication of poor soil stability. The annual cropping system had a compacted layer at 11 cm where roots will not growth properly. Chemical evaluation of the remediation site showed nutrient constraints: low availability of P, with high or very high K, Fe, Mn N and Mg which could be causing antagonism with other nutrients uptake by the roots (Annex B-LR-Oats-Chemicals).

Table 3. **Mean averages of canola yields, bushel weight and TKW affected by different sources of humic materials in Canola (Liberty 1234).**

	Annual Cropping System-Canola		
Treatments	**Yield (bu/a)**	**Bushel Weight (lb/bu)**	**TKW***
NPK-Control	29	55	10
RH100	38	54	11
RH250	30	54	10
RH100Sift	33	54	11
RH250Sift	30	55	10
Humi(K)2	30	54	10
Humi(K)4	34	54	11
PH-CH250	32	55	10
PH-BE250	33	55	11

*TKW: Thousand Kernel weight

Table 3 shows the average yield, bushel weight and TKW of canola by treatment. The highest yield found was RH treatment at 100 lb/A with 38 bu/A but it was not statistically significant when compared with the other treatments. Statistical analysis indicated that there were not statistically significant differences among treatments applications for both sites. The reason was due to the high variability in responses within treatments as it is seen in Figure 1, 2 and 3 for canola yield, oats biomass and crude protein. A large portion of the bar above and below the mean is an indication of high yield variability within that treatment as it can be observed for RH100 treatment for canola (Figure 1), RH250 treatment for Oats Biomass (Figure 2) and Humi(k)4 treatment for Oat biomass crude protein (Figure3). However, applications of these materials showed a trend of increasing canola yield up to 9 bu/A when compared with the control but not statistically significant.

Table 4, 5 and 6 show the responses in Oat biomass and feed quality, micro and macro nutrients uptake by oats treated with humic materials. The highest biomass average was for treatment humi(k)2 with 3651 lb/A, followed by RH250 with 3115 lb/A. These yields were below the average 2020 yield for an oat silage trial (4000lb/A) grown under similar climatic conditions. Fig 2 shows that these two treatments has a huge variability (bar above and below average yield) in yield response of at least 1000 lb/A. A similar trend of positive response compared with the control was also observed in biomass production when the humic materials were applied except for PH-BE250 and PH-CH250. Applications of these materials show a trend of increasing biomass up to 1100 bu/A when compared with the control but not statistically significant among treatments.

Figure 1. **Mean of Canola yields with 95% coefficient of Interval (variation) within mean (bar above & below yield) in bu/A**

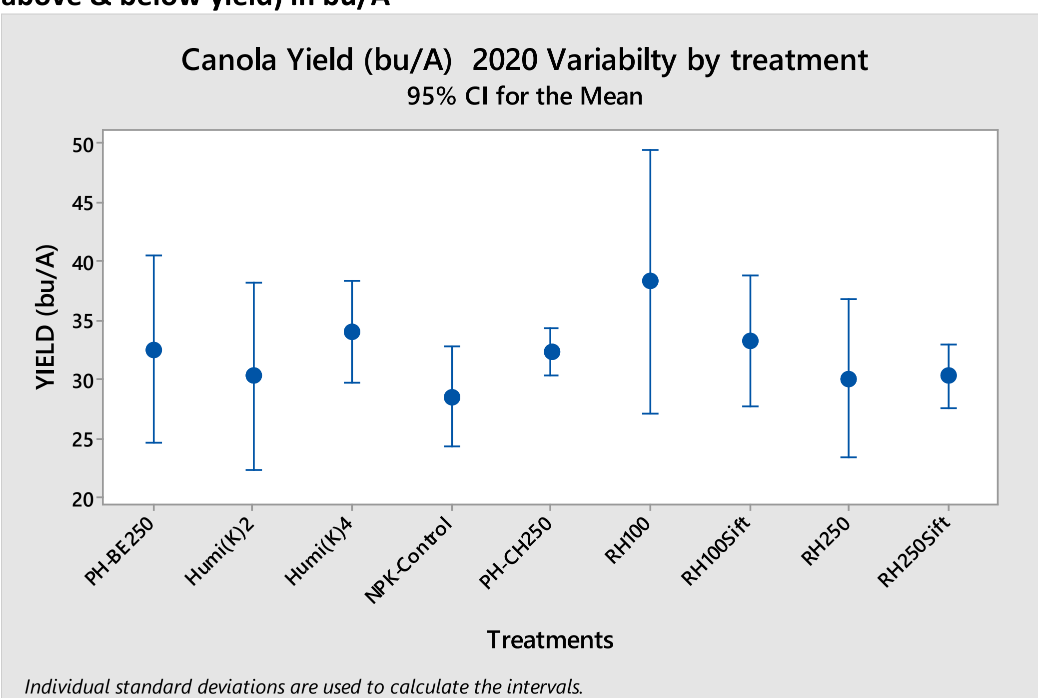

Figure 2. **Mean averages Oats biomass with 95% coefficient of Interval (variation) within mean (bar above & below yield) in lb/A**

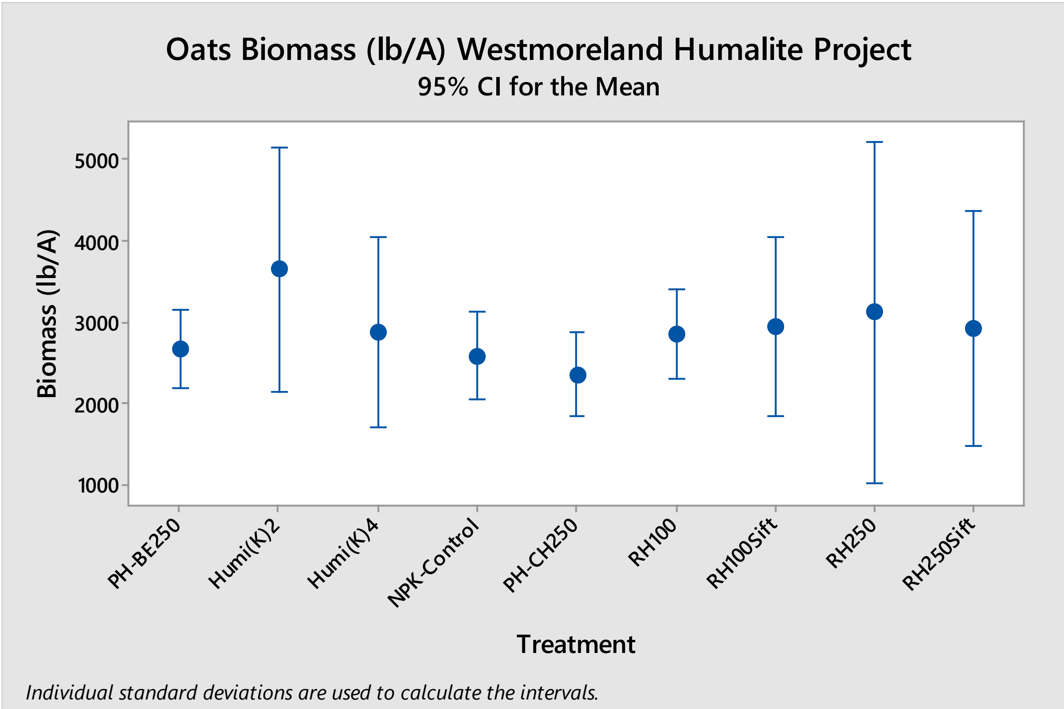

Figure 3. **Mean averages Oats Crude protein with 95% coefficient of Interval (variation) within mean (bar above & below yield) in %**

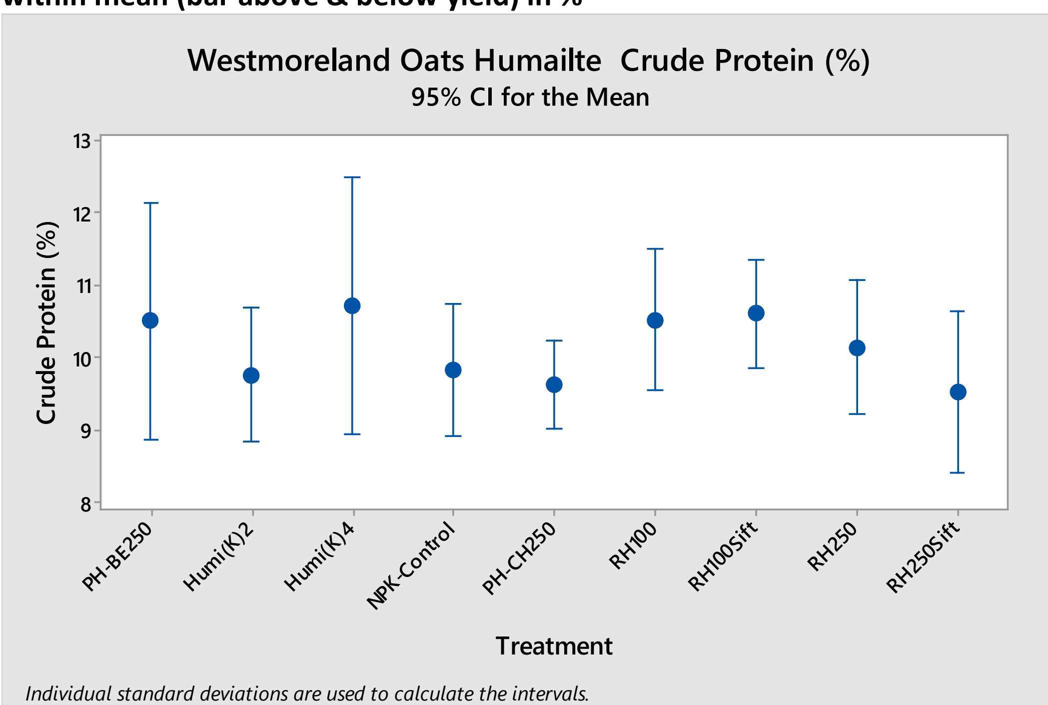

Table 4. Mean averages of Oat Biomass and feed quality analysis at the Land Remediation site affected by humic materials.

	Land Remediation Site					
Treatments	**Oat Biomass lb/A**	**Crude Protein**	**RFV**	**ADF**	**NDF**	**TDN**
		-------------------------%------------------------				
NPK	2575	10	129	36	44	67
RH100	2840	11	139	35	42	69
RH250	3115	10	129	36	44	67
RH100Sift	2942	11	130	36	44	67
RH250Sift	2913	10	128	37	44	67
Humi(K)2	3651	10	125	37	45	66
Humi(K)4	2877	11	124	36	46	66
PH-250	2348	10	134	35	43	68
BEH-250	2664	11	133	35	43	68

While crude protein and Zn of the oat biomass samples were in the desired levels, analyses of the oats' biomass showed some of the nutrients were not in balance for complete cattle rations. This could be attributed to the unbalanced nutrients in the soil (low P, high N, K, Mg). Biomass nutrient levels were low for P, Ca and Cu, high high for K, Mg, Fe and Mn. Biomass nutrient uptake might have been affected by the antagonist effect of some nutrients which were high in the soil. Low P availability in the soil might justify the low P value in the tissue. Calcium uptake might have been affected by the high level of Mg, Ca and/or Na in the soil even though its soil level was adequate (medium) and the low biomass Cu uptake might have being affected by high Mn in the soil (Tables 5 and 6 and Annex B-LR-Oats-Chemicals).

Table 5. **Mean averages of Oat Biomass and feed quality analysis for Macronutrients at the Land Remediation site affected by humic materials.**

Treatments	**Calcium**	**Phosphorus**	**Potassium**	**Magnesium**	**Sulphur**
	-----------------------------%---------------------------				
NPK	0.27	0.19	1.65	0.18	0.17
RH100	0.31	0.21	1.78	0.20	0.18
RH250	0.31	0.19	1.74	0.19	0.17
RH100Sift	0.34	0.19	2.02	0.21	0.18
RH250Sift	0.27	0.17	1.78	0.18	0.16
Humi(K)2	0.30	0.18	2.00	0.19	0.16
Humi(K)4	0.34	0.18	1.84	0.21	0.17
PH-250	0.30	0.20	1.64	0.20	0.17
BEH-250	0.29	0.19	1.84	0.19	0.17

Table 6. **Mean averages of Oat Biomass and feed quality analysis for Micronutrients at the Land Remediation site affected by humic materials.**

	Copper	Iron	Mn	Zn
Treatments	--------------------------**ug/g**----------------------------			
NPK	3.38	276	117	38
RH100	3.01	271	126	42
RH250	3.30	438	116	40
RH100Sift	3.63	310	105	39
RH250Sift	3.31	318	94	36
Humi(K)2	3.53	317	94	37
Humi(K)4	2.97	281	118	42
PH-250	3.28	377	130	41
BEH-250	3.34	324	121	39

Conclusions:

Data collected during 2020 in both sites using the same treatments showed a high variability in yield responses regardless of good moisture during the growing season. Canola average yields were higher for humic material treatments compared with the control, but they were not statistical significantly due to variability within treatment plots. Base on this year's evaluation, it could be inferred that addition of humic material might have a potential to improve crop performance over time by eliminating some of the soil health constraints. To accomplish this, each system will need to be addressed in a way that will allow soil biology to improve by including into these systems not only a rotation with a cocktail crop but also inoculants with healthy biology to speed the process of soil healing along with the humic materials. Treating these sites as a whole entity will enhance soil biology which might start improving soil physical constraints while balancing its chemical properties (nutrient availability). For all the above, it will be important to evaluate these humic materials for a longer period to accomplish and understand their role in soil healing.

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Annex A- AC-CANOLA

CARA SHLab

SOIL HEALTH LAB REPORT

CARA-Humalite-Canola
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Lab Submission 1-002338

LAB #	SAMPLE NAME	DEPTH (inches)	LAND LOCATION	ASSESSMENT	OBSERVATIONS
750	Humalite	0-3	NW 33-30-11-W4	Benchmark	
751		3-6			
755		0-6			
756		6-12			

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Annex A- AC-CANOLA-Biophysical & Others

Submission N/Land Location	Farmer Id No.	Sample No.	Depth (cm)	% Sand	% Silt	% Clay	Textural Class:	
1-002338	Humalite	750	0-7.5	60	33	7	Coarse	Sandy Loam
		751	7.5-15	60	29	11	Coarse	Sandy Loam
		756	15-30	70	22	7	Coarse	Sandy Loam

Soil Health Analysis: Biophysical & Others

	Indicator	Results 750	Results 751	Results 756	Score 750	Score 751	Score 756	Constraint(s)
Physical	Wet Aggregate Stability (%)	21	14	14	20	13	17	Soil pore space, aeration, water infiltration, rooting, soil crusting and sealing, wind and water erosion, runoff
Physical	Water Infiltration (min)	N/A	N/A	N/A	####	####	###	#VALUE!
Physical	Bulk Density (g/cm3)	1.14	0.91	0.78	100	100	100	
Physical	Compaction Depth/cm (200psi)	6	6	6	9	9	9	Short: Mechanical soil loosening (strip till, aerators, broadfork, spader) • deep & shallow-rooted cover crops •Living mulch, cocktail cover crop. Long term: Avoid traffic on wet soils
Physical	Compaction Depth/cm (300psi)	11	11	11	0	0	0	Short: Mechanical soil loosening (strip till, aerators, broadfork, spader) • deep & shallow-rooted cover crops •Living mulch or interseed cover crop. Long term: Avoid traffic on wet soils, tillage/loads. Use controlled traffic patterns/lanes.
Physical Health:								
Biological	Organic Matter (%)	2	2	2	34	34	34	Water retention, soil erosion, aggregate stability, fertility, nutrient cycling, biological activity, cation exchange capacity, bulk density, soil structure, carbon storage
Biological	Active Carbon (ppm)	256	88	57	17	4	4	Water infiltration, microbial biomass growth and activity, nutrient cycling, carbon storage, aggregate stability, bulk density, nutrient availability, supply of labile carbon
Biological	Sample Depth	0-7.5				7.5-15		15-30
Biological	TN (%) (Total Nitrogen)	0.18				0.16		0.09
Biological	TC (%) (Total Carbon)	1.75				1.44		0.68
Biological	TOC (%) (Total Organic Carbon)	1.74				1.31		0.58
Biological	C:N Ratio	10	9	7	99	100	100	
Biological	Microbial Respiration (mg CO_2/g)	0.28	0.25	0.17	14	12	12	Soil microbial activity and abundance, organic matter decomposition, nutrient transformation and release potential, aggregate formation and stabilization
Biological Health:								

Physical and Biological Indicator Scores are calculated using the cumulative normal distribution function for Coarse, Medium, and Fine textural classes. Depending on the measured soil texture distribution, this worksheet identifies the appropriate soil textural class and uses the corresponding Scoring Function. Each Indicator Score represents the percentage of all samples scoring at or below the measured value when compared across the complete sample database. Indicator Scores are assigned a color grade using the follows system: Very High, Score of 80-100 (Blue); High, Score of 60-80 (Green); Medium, Score of 40-60 (Yellow); Low, Score of 20-40 (Orange); Very Low, Score of 0-20 (Red). For Other Nutrients Ratings, a Score of 1 is best (blue) and 0 is worst (red).

Submission N/Land Location	Farmer Id No.	Sample No.	Depth (cm)
1-002338	Humalite	750	0-7.5
		751	7.5-15

% Sand	% Silt	% Clay	Textural Class:	
60	33	7	Coarse	Sandy Loam
60	29	11	Coarse	Sandy Loam

Soil Health Analysis: Biophysical & Others

	Indicator	Results 750	Results 751	Score 750	Score 751	Suggestion(s)
Physical	Wet Aggregate Stability (%)	21	14	20	13	Short: Improve soil Biology diversity • Use deep & shallow-rooted cover (cocktail) /rotation crops • Add manure, green manure, mulch. Long: Reduce tillage • Rotate with sod crops • Incorporate high biomass cover (cocktail) crop
	Water Infiltration (min)	N/A	N/A	####	###	#VALUE!
	Bulk Density (g/cm3)	1.14	0.91	100	100	
	Compaction Depth/cm (200psi)	6	6	9	9	Short: Mechanical soil loosening (strip till, aerators, broadfork, spader) • deep & shallow-rooted cover crops •Living mulch, cocktail cover crop. Long term: Avoid traffic on wet soils /tillage/loads.
	Compaction Depth/cm (300psi)	11	11	0	0	Short: Mechanical soil loosening (strip till, aerators, broadfork, spader) • deep & shallow-rooted cover crops •Living mulch or interseed cover crop. Long term: Avoid traffic on wet soils
Physical Health:						
Biological	Organic Matter (%)	2	2	34	34	Add stable organic materials, mulch • Add compost and organic amendments • Incorporate rotation with cocktail
	Active Carbon (ppm)	256	88	17	4	Short: Add fresh organic materials • Use shallow & deep-rooted cover/rotation crops • Add manure, green manure, mulch. Long: Reduce tillage • Rotate with sod crop • Cocktail Cover crop
	C:N Ratio	10	9	99	100	
	Microbial Respiration (mg CO_2/g)	0.28	0.25	14	12	Short: Mantain plant cover whole season • Add fresh OM• Add manure, green manure • reduce biocide usage. Long: Reduce tillage/mechanical cultivation •
Biological Health:						

Annex A- AC-CANOLA-SFW

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Lab Submission #: **1-002338**

Soil Foodweb Analysis

CARA-Humalite-Canola
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Fax:
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Plants: canola
Sample Received: 5/22/2020
Invoice Numb 1-002338

Organism Biomass Data

Sample #	Unique ID	Depth Inches	Active Bacterial Biomass (µg/g)	Total Bacterial Biomass (µg/g)	Active Fungal Biomass (µg/g)	Total Fungal Biomass (µg/g)	Average Hyphal Diameter (µm)	Protozoa Numbers/g Flagellates	Protozoa Numbers/g Amoebae	Protozoa Numbers/g Ciliates	Total Nematode (Dry Weight) #/g
750	Humalite	0-3	13	2,182	13	388	4.1	2,969	14,843	6	11.0
751	Humalite	3-6	12	5,324	0	236	3.5	3,070	509	0	3.7
755	Humalite	0-6	15	2,879	0	129	3.5	4,929	615	6	4.6
756	Humalite	6-12	9	3,226	0	75	3.0	890	6,154	0	1.1
Desired Range Pasture			10 - 25	150 - 300	10 - 25	150 - 300	(A)	10000 +	10000 +	50 - 100	20 - 30
Desired Range Canola			10 - 25	100 - 200	2 - 10	50 - 100	(A)	5000 +	5000 +	50 - 100	10 - 20

(A) Hyphal diameter of 2.0 indicates mostly actinobacteria hyphae, 2.5 indicates community is mainly ascomycete, typical soil fungi for grasslands, diameters of 3.0 or higher indicate community is dominated by highly beneficial fungi, a Basidiomycete community.

Organism Ratios

Sample #	Unique ID	Depth Inches	Total Fungal To Total Bacterial Biomass	Active to Total Fungal Biomass	Active to Total Bacterial Biomass	Active Fungal to Active Bacterial Biomass	Nematode Feeding Habit Identified #/g (Wet Soil) BactF	FungF	RootF	Pred
750	Humalite	0-3	0.178	0.033	0.006	0.960	6.56	1.31	2.40	0.00
751	Humalite	3-6	0.044	0.000	0.002	0.000	1.52	0.21	1.63	0.00
755	Humalite	0-6	0.045	0.000	0.005	0.000	2.63	0.20	1.46	0.00
756	Humalite	6-12	0.023	0.000	0.003	0.000	0.54	0.10	0.40	0.00
Desired Range			*(1)	*(2)	*(2)	*(3)			*(4)	

(1) Brassica: 0.2-0.5; Row crops: 0.6 to 1.2; Early successional grass: 0.5-0.75; Late successional grass: 0.8 to 1.5; Berries, shrubs, vines: 2-5; Deciduous Trees: 5-10; Conifer: 10-100.
(2) Warm spring, early summer: 0.25 to 0.95; Early spring, late winter & mid-summer: 0.10 to 0.15; Fall rain: 0.15 to 0.20; Drought/frozen soil/heavy metal/many pesticides: 0.05 or lower. Values greater than indicated mean the organisms are recovering from a negative impact. Values lower mean organisms are not recovering and help is needed, typically addition of their food resource is required.
(3) Generally 1:1 results in good soil aggregate structure in crop soil; 2 to 5 for deciduous trees; 5 for conifers. Values above 1:1 mean negative impact. Values lower mean organisms are not recovering and help is needed, typically addition of their food resource is required.
(4) Identification of Todes feeding groups: (BactF) Bacteria, (FungF) Fungal, (Pred) Predatory, (RootF) Plant/Root,

Season, moisture, soil and organic matter must be considered in determining optimal foodweb structure. All submissions receive free 15 minute consultation, call +1 403 664 3777

Notes: Protozoa numbers and types are an estimate of their appearance when counting them base on shapes, movements, sizes, colors, etc

Sample	Protozoa Types Numbers (At Least) Flagellates	Ciliates	Amoeba	Fungal Hyphae Colors*	Diam (um)	Other Comments**
750	14	1	5	C, LB	3.3-8.3	Spore germinating (lots differents sizes), dominated by Cocci bacterias, large flagellates, Laimydorus doryuris (fungal feeder not seen before: 70.4.2reference), lots of root f with nematophagus
751	8	0	3	C	2-4.3	lots spores (DB) germinating, dominated by Cocci bacterias, large flagellates, low flagellates in wells
755	15	1	4	C, T	2-5	diversity bacteria (cocci and diplococci)
756	7	0	2	C, T	2-4.2	diversity bacteria (cocci and rob)

* C:Clear, B Brown, LB: Light Brown, DB: Dark Brown, Burg:Burgandy, T:Tan, LC-well-Flag: low count flagellates in wells, Very-tiny Flag: very tiny flagellates
** 24h-Spore-Germ: 24 hours spores germinating, D or Diam: diameter

CARA SHLab

SOIL HEALTH LAB REPORT

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Lab Submission # 1-002355

LAB #	SAMPLE NAME	DEPTH (inches)	LAND LOCATION	ASSESSMENT	OBSERVATIONS
980	Westmoreland	0-6	SE 25-29-13-W4	Benchmark	
981		6-12			
982		12-18			
983		18-24			

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Annex B- LR-Oats-Biophysical & Others

Submission N/Land Location	Farmer Id No.	Sample No.	Depth (cm)	% Sand	% Silt	% Clay	Textural Class:	
1-002355	Westmoreland	980	0-15	39	37	23	Medium	Loam
1-002355		981	15-30	42	35	23	Medium	Loam
1-002355		982	30-45	47	29	24	Medium	Loam

Soil Health Analysis: Biophysical & Others

	Indicator	Results 980	Results 981	Results 982	Score 980	Score 981	Score 982	Constraint(s)
Physical	Wet Aggregate Stability (%)	18	10	19	24	13	10	Soil pore space, aeration, water infiltration, rooting, soil crusting and sealing, wind and water erosion, runoff
	Water Infiltration (min)	11	11	11	99	99	99	
	Bulk Density (g/cm3)	0.92	N/A	N/A	100	####	###	
	Compaction Depth/cm (200psi)	25	25	25	100	100	100	
	Compaction Depth/cm (300psi)	35	35	35	76	76	76	
Physical Health:								
Biological	Organic Matter (%)	4.6	4.6	4.6	91	91	91	
	Active Carbon (ppm)	208	779	944	6	93	93	
	Sample Depth	0-15			15-30			30-45
	TN (%) (Total Nitrogen)	0.25			0.53			0.62
	TC (%) (Total Carbon)	3.43			16.45			21.81
	TOC (%) (Total Organic Carbon)	3.42			16.44			21.53
	C:N Ratio	14	31	35	94	0	0	Slow SOM decay , organic matter quality, microbial activity and abundance, nutrient cycling and transformation, mineralizable nitrogen
	Microbial Respiration (mg CO_2/g)	0.52	1.25	1.79	39	98	98	
Biological Health:								

Physical and Biological Indicator Scores are calculated using the cumulative normal distribution function for Coarse, Medium, and Fine textural classes. Depending on the measured soil texture distribution, this worksheet identifies the appropriate soil textural class and uses the corresponding Scoring Function. Each Indicator Score represents the percentage of all samples scoring at or below the measured value when compared across the complete sample database. Indicator Scores are assigned a color grade using the follows system: Very High, Score of 80-100 (Blue); High, Score of 60-80 (Green); Medium, Score of 40-60 (Yellow); Low, Score of 20-40 (Orange); Very Low, Score of 0-20 (Red). For Other Nutrients Ratings, a Score of 1 is best (blue) and 0 is worst (red).

Submission N/Land Location	Farmer Id No.	Sample No.	Depth (cm)
1-002355	Westmoreland	980	0-15
1-002355	0	981	15-30

% Sand	% Silt	% Clay	Textural Class:	
39	37	23	Medium	Loam
42	35	23	Medium	Loam

Soil Health Analysis: Biophysical & Others

	Indicator	Results 980	Results 981	Score 980	Score 981	Suggestion(s)
Physical	Wet Aggregate Stability (%)	18	10	24	13	Short: Improve soil Biology diversity • Use deep & shallow-rooted cover (cocktail) /rotation crops • Add manure, green manure, mulch. Long: Reduce tillage • Rotate with sod crops • Incorporate high biomass cover (cocktail) crop
Physical	Water Infiltration (min)	11	11	99	99	
Physical	Bulk Density (g/cm3)	0.92	N/A	100	#VALUE!	
Physical	Compaction Depth/cm (200psi)	25	25	100	100	
Physical	Compaction Depth/cm (300psi)	35	35	76	76	
Physical Health:						
Biological	Organic Matter (%)	4.6	4.6	91	91	
Biological	Active Carbon (ppm)	208	779	6	93	
Biological	C:N Ratio	14	31	94	0	
Biological	Microbial Respiration (mg CO_2/g)	0.52	1.25	39	98	
Biological Health:						

Report Number: C20185-10041
Account Number: 01207

A & L Canada Laboratories Inc.

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C20185-10041

To: CHINOOK APPLIED RESEARCH ASSOC
BOX 690
HIGHWAY 41 EAST
OYEN, AB T0J 2J0

For: CARA SHL SN 1-002355

Annex B-LR-Oats-Chemicals

Grower Code: 1-002355

Reported Date: 2020-07-07   **Printed Date:** Jul 7, 2020

SOIL TEST REPORT

Sample Number	Legal Land Descpt:	Depth	Lab Number	Organic Matter	Phosphorus - P ppm Bicarb	Phosphorus - P ppm Bray-P1	Potassium K ppm	Magnesium Mg ppm	Calcium Ca ppm	pH	pH Buffer	CEC meq/100g	% K	% Mg	% Ca	% H	% Na
980	WESTMORELAND	0	06757	4.6	14 L	23 L	280 VH	560 H	2430 M	6.4	6.9	19.1	3.8	24.5	63.7	6.0	2.1
981	WESTMORELAND	0	06758														
982-983	WESTMORELAND	0	06759														

(Percent Base Saturations: % K, % Mg, % Ca, % H, % Na)

Sample Number	Sulfur S ppm	Sulfur S lbs/ac	Nitrate Nitrogen NO3-N ppm	Nitrate Nitrogen NO3-N lbs/ac	Zinc Zn ppm	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	Soluble Salts mmhos/cm	Saturation %P	Aluminum Al ppm	Saturation %Al	K/Mg Ratio	ENR	Chloride Cl ppm	Sodium Na ppm
980	59 M		20 H		4.1 M	33 H	81 VH	0.9 M	0.9 M	0.6 L	4 M	734	0.2 G	0.16	59	13	94 VH
981	297 VH		39 H														
982-983	406 VH		31 H														

W VL = VERY LOW, L = LOW, M = MEDIUM, H = HIGH, VH = VERY HIGH, G = GOOD, MA = MARGINAL, MT = MODERATE PHYTO-TOXIC, T = PHYTO-TOXIC, ST = SEVERE PHYTO-TOXIC

SOIL FERTILITY GUIDELINES (lbs/ac)

Sample Number	Previous Crop	Intended Crop	Yield Goal	Lime Tons/Acre	N	P2O5	K2O	Mg	Ca	S	Zn	Mn	Fe	Cu	B
980		Oats	60 bu	0.0	75	15	15	0	0	0	0.0	0	0	1	0.0
980		Oat Build	60 bu	0.0	75	20	25	0	0	0	0.0	0	0	1	0.0

Annex B- LR-Oats- SFW

CARASHLab
Highway 41E,
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Soil Foodweb Analysis
Humalite Project
CARA- 2020 Oats
Box 690
Oyen, Alberta T0J2J0
Fax:
carashl@telus.net
Plants: grass
Sample Received: 6/24/2020
Invoice Numb 1-002355

Lab Submission #: **1-002355**

Organism Biomass Data

Sample #	Unique ID	Depth Inches	Active Bacterial Biomass (µg/g)	Total Bacterial Biomass (µg/g)	Active Fungal Biomass (µg/g)	Total Fungal Biomass (µg/g)	Average Hyphal Diameter (µm)	Protozoa Numbers/g Flagellates	Protozoa Numbers/g Amoebae	Protozoa Numbers/g Ciliates	Total Nematode (Dry Weight) #/g
980	Westmoreland	0-6	35	14,670	0	145	3.1	3,289	203	7	1.0
981	Westmoreland	6-12	7	17,940	0	66	2.8	2,608	208	7	0.3
982	Westmoreland	12-18	1	21,067	0	14	2.0	102	0	0	0.0
983	Westmoreland	18-24	1	19,172	0	0	0.0	39	0	0	0.0
Desired Range Pasture			10 - 25	150 - 300	10 - 25	150 - 300	(A)	10000 +	10000 +	50 - 100	20 - 30
Desired Range Annual crops			1 - 5	175 - 300	1 - 5	175 - 300	(A)	5000 +	5000 +	50 - 100	10 - 20

(A) Hyphal diameter of 2.0 indicates mostly actinobacteria hyphae, 2.5 indicates community is mainly ascomycete, typical soil fungi for grasslands, diameters of 3.0 or higher indicate community is dominated by highly beneficial fungi, a Basidiomycete community.

Organism Ratios

Sample #	Unique ID	Depth Inches	Total Fungal To Total Bacterial Biomass	Active to Total Fungal Biomass	Active to Total Bacterial Biomass	Active Fungal to Active Bacterial Biomass	Nematode Feeding Habit Identified #/g (Wet Soil) BactF	FungF	RootF	Pred
980	Westmoreland	0-6	0.010	0.000	0.002	0.000	0.54	0.28	0.00	0.00
981	Westmoreland	6-12	0.004	0.000	0.000	0.000	0.23	0.05	0.00	0.00
982	Westmoreland	12-18	0.001	0.000	0.000	0.000	0.01	0.01	0.00	0.00
983	Westmoreland	18-24	0.000	0.000	0.000	0.000	0.00	0.01	0.00	0.00
Desired Range			*(1)	*(2)	*(2)	*(3)		*(4)		

(1) Brassica: 0.2-0.5; Row crops: 0.6 to 1.2; Early successional grass: 0.5-0.75; Late successional grass: 0.8 to 1.5; Berries, shrubs, vines: 2-5; Deciduous Trees: 5-10; Conifer: 10-100.
(2) Warm spring, early summer: 0.25 to 0.95; Early spring, late winter & mid-summer: 0.10 to 0.15; Fall rain: 0.15 to 0.20; Drought/frozen soil/heavy metal/many pesticides: 0.05 or lower. Values greater than indicated mean the organisms are recovering from a negative impact. Values lower mean organisms are not recovering and help is needed, typically addition of their food resource is required.
(3) Generally 1:1 results in good soil aggregate structure in crop soil; 2 to 5 for deciduous trees; 5 for conifers. Values above 1:1 mean negative impact. Values lower mean organisms are not recovering and help is needed, typically addition of their food resource is required.
(4) Identification of Todes feeding groups: (BactF) Bacteria, (FungF) Fungal, (Pred) Predatory, (RootF) Plant/Root,
Season, moisture, soil and organic matter must be considered in determining optimal foodweb structure. All submissions receive free 15 minute consultation, call +1 403 664 3777

Notes: Protozoa numbers and types are an estimate of their appearance when counting them base on shapes, movements, sizes, colors, etc

Sample	Protozoa Types Numbers (At Least) Flagellates	Ciliates	Amoeba	Fungal Hyphae Colors*	Diam (um)	Other Comments**
980	11	1	2	C, T	2-4.5	actinobacteria, lots of very tiny mobile bacteria, 2 um D septated tan hypha, round flagellates and oval with bacteria like interacting attached, rugosa amoeba, few amoeba and flagellates in wells, rotifers
981	7	1	3	C	2-3	very tiny mobile bacteria, few round flagellates, tiny & small/ few flagellates, very tiny amoebae
982	5	0	0	C	2	low flagellates,
983	2	0	0	NA	NA	Actinobacteria, very low flagellates

* C:Clear, B Brown, LB: Light Brown, DB: Dark Brown, Burg:Burgandy, T:Tan, LC-well-Flag: low count flagellates in wells, Very-tiny Flag: very tiny flagellates
** 24h-Spore-Germ: 24 hours spores germinating, D or Diam: diameter