Develop instrumental methods for mold evaluation and foreign crops detection of flax and hemp straws

-- A NIR approach

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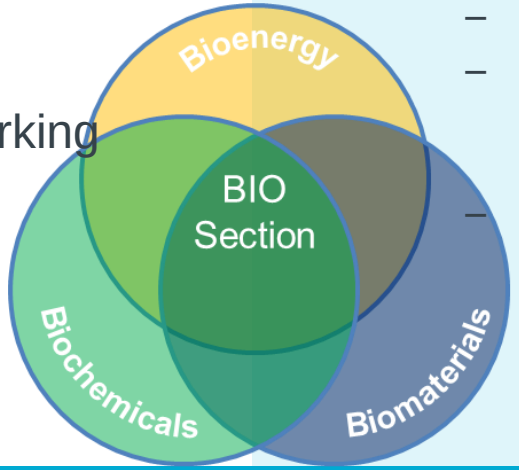
Alberta Agriculture and Forestry

Bio-Industrial Opportunities Section

- Diversifying economic opportunities for biomass and by-products
- Maximizing value through fractionation for ingredients and intermediates
- Facilitate commercialization and market access

Business Development Services

- Business planning
  - Market/feasibility research
  - Access to funding
- Strategic counsel
  - Supply chain logistics
  - Market access
  - Regulations and policy
- Collaboration and networking
  - Academia/Industry
  - Municipalities
  - Regulatory
- Industry Advocacy



Technical Services

- Multi-disciplinary skill sets:
  - Science
  - Engineering
  - Technical operators
- Facility:
  - Laboratory & Pilot scale
  - Expertise in innovate emerging value added industries and technologies
  - Allow companies to develop and test their prototype processes or products

Project background

Fiber quality

and

Biomass Quality Networks Canada



Alberta

Fibre Quality Considerations

- In Canada, quality standards have not been fully determined for fibre crops.
  - Moisture Content
  - Mold
  - Foreign matters
    - Weed/volunteer cereal crops
    - Stones
    - Plastic



Overall objective

- The appropriate assessment of feedstocks and semi-processed material of biomass helps improve the trade of material throughout the supply chain.
  - relatively inexpensive
  - easy to perform
  - quick to carry out
  - give reasonably repeatable and meaningful results
  - to be upgraded to more sophisticated methods.

Near Infrared (NIR) spectrometer

- Viable for characterizing some agricultural samples, food, feed, and to predict constituents.
- Experience on textile fabrics sorting

Fast NIR approach



Mold and foreign matters test

Objective

- Develop an instrumental, non-destructive spectral (VIS-)NIR testing methods to,
  - To simulate the subjective evaluation of experts in terms of mold level
  - To quantify the percentage of weed crops in bale

Materials and methodology

Mold level test

- 64 hemp, and 43 flax mold straws
- Scored (1-5) by experts from AB, SK, and MB.



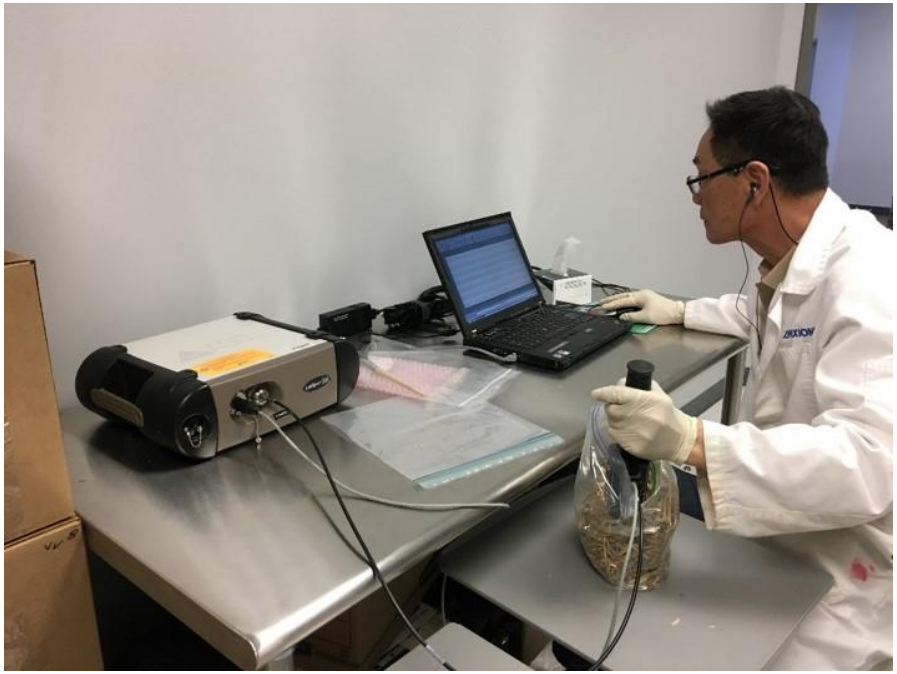
Foreign crops

- Hemp and flax as primary straw, respectively
- 6 weeds/crops: wheat, barley, canola; wild oats, kochia, and thistle
- 88 combinations (up to 30%) each of hemp or flax
- 5 and 8 scanning spot comparison

Mixture

Primary	wheat	wild oats	barley	canola	kochia	Thistle	Sample #
95%	5	0	0	0	0	0	1
C(6,1) = 6 combinations	0	5	0	0	0	0	2
	0	0	5	0	0	0	3
	0	0	0	5	0	0	4
	0	0	0	0	5	0	5
	0	0	0	0	0	5	6
70%	15	15	0	0	0	0	7
C(6,2) = 15 combinations	15	0	15	0	0	0	8
	15	0	0	15	0	0	9
	15	0	0	0	15	0	10
	15	0	0	0	0	15	11
	0	15	15	0	0	0	12
	0	15	0	15	0	0	13
	0	15	0	0	15	0	14
	0	15	0	0	0	15	15
	0	0	15	15	0	0	16
	0	0	15	0	15	0	17
	0	0	15	0	0	15	18
	0	0	0	15	15	0	19
	0	0	0	15	0	15	20
	0	0	0	0	15	15	21
70%	10	10	10	0	0	0	22
	10	10	0	10	0	0	23
	10	10	0	0	10	0	24
	10	10	0	0	0	10	25
	10	0	10	10	0	0	26
	10	0	10	0	10	0	27
	10	0	10	0	0	10	28
	10	0	0	10	10	0	29

LabSpec 5000

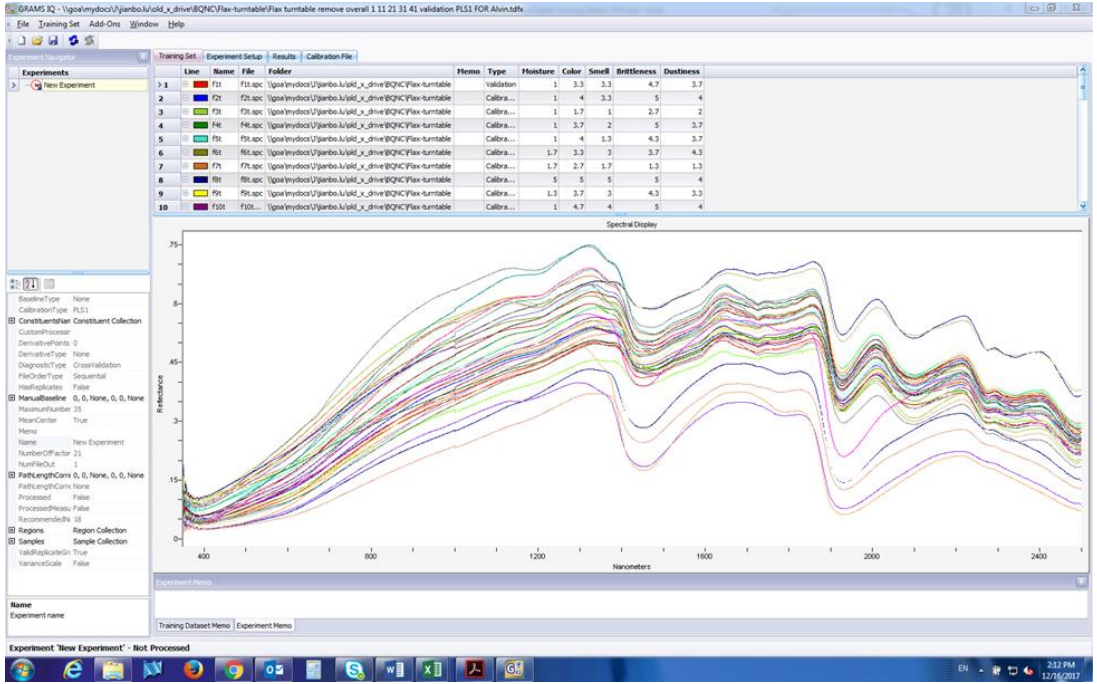






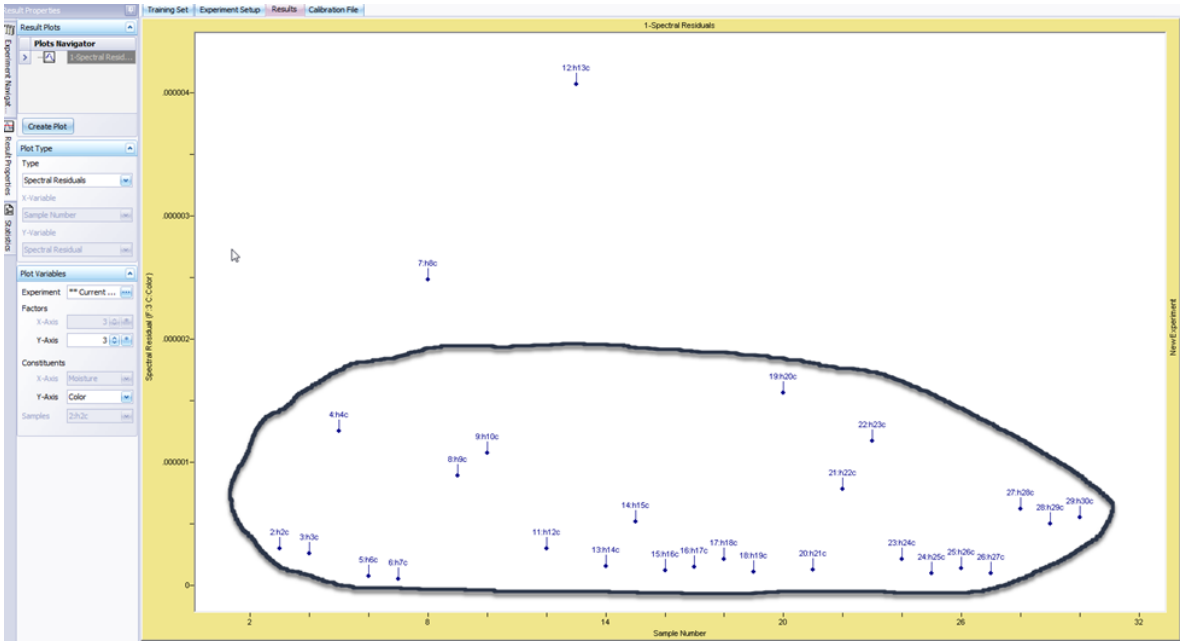
Calibration--GRAMS IQ

- Training set
- Experiment setup
  - Calibration Type
  - Diagnostic Type
  - Data Preprocessing
- Results
- Calibration file



Outliers

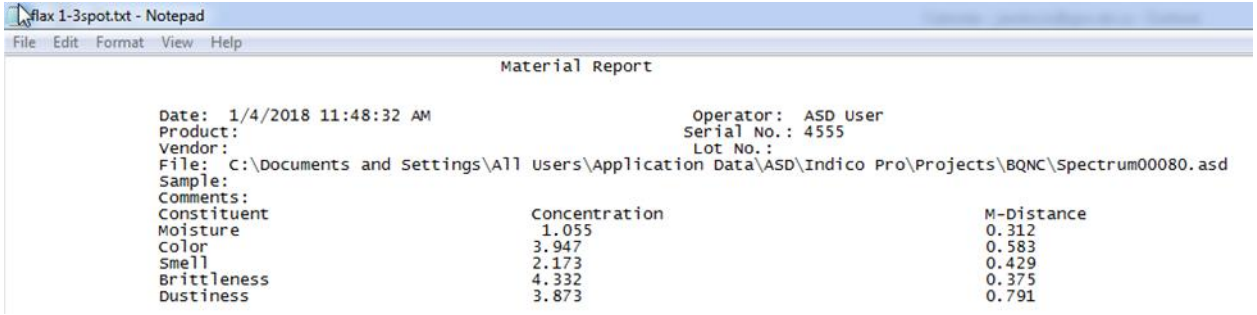
- Spectral residuals
- Concentration residuals
- Score vs score



Validation and selection

	Prediction error from expert scoring (%)							
Sample	Moisture	Color	Smell	Brittlenes	Dustiness	Factors		
1	53.0	5.8	68.0	-1.5	-19.0	PLS1	Overall variation of constituents (%)	STD. P.
11	-0.1	-5.8	8.7	-15.6	17.3			
31	0.5	-4.0	-5.3	85.4	-6.5			
	20.9	2.3	-3.3	11.5	6.8		4.3	5.5
	28.6	2.2	20.2	29.4	16.3	PCR	17.0	9.8
Mean	26.4	-6.6	34.7	27.8	24.6	PLS2	20.1	15.8

Prediction


flax 1-3spot.txt - Notepad

File Edit Format View Help

Material Report

Date: 1/4/2018 11:48:32 AM Operator: ASD User
Product: Serial No.: 4555
Vendor: Lot No.:
File: C:\Documents and Settings\All Users\Application Data\ASD\Indico Pro\Projects\BQNC\Spectrum00080.asd
Sample:
Comments:

Constituent	Concentration	M-Distance
Moisture	1.055	0.312
Color	3.947	0.583
Smell	2.173	0.429
Brittleness	4.332	0.375
Dustiness	3.873	0.791

	Prediction error from expert scoring (%)					Variation of constituents (%)	STD. P.	Variation of constituents (%)	STD. P.
	Moisture	Color	Smell	Brittleness	Dustiness	with moisture		without moisture	
Real-time	1.0	5.5	18.4	-34.8	-7.2	-2.5	18.1	-4.5	19.7
Predict from file	1.0	4.0	22.4	-30.4	-6.6	-1.5	17.2	-2.9	19.0

Foreign crops/weeds

Flax PLS1		Flax	wheat	wild oats	barley	canola	kochia	Thistle	Weed	STD. P of weeds
5 spots	Mean of error	7.38	-2.52	-1.97	2.18	2.25	0.75	-4.27	-3.59	
	Average % in mixtures	67.78	8.61	2.78	2.22	4.17	4.72	9.72	32.22	
	Variation (%)	10.89	-29.31	-70.91	98.00	53.99	15.91	-43.94	-11.13	58.45
5 spots outliers	Mean of error	-1.02	1.16	0.69	-0.94	-0.50	-1.57	-0.16	-1.32	
	Average % in mixtures	76.25	3.44	3.13	2.50	4.69	5.31	4.69	23.75	
	Variation (%)	-1.34	33.83	22.11	-37.78	-10.71	-29.65	-3.34	-5.57	25.68
F8 spots	Mean of error	2.85	-3.02	0.29	1.92	-1.60	1.25	-4.81	-2.85	
	Average % in mixtures	67.78	8.61	2.78	2.22	4.17	4.72	9.72	32.22	
	Variation (%)	4.21	-35.07	10.34	86.54	-38.38	26.38	-49.51	-8.85	47.34
8 spots outliers	mean	-0.64	2.08	1.97	1.37	-1.14	-1.91	-1.68	0.64	
	Average % in mixtures	76.25	3.44	3.13	2.50	4.69	5.31	4.69	23.75	
	Variation (%)	-0.83	60.52	63.03	54.76	-24.36	-35.96	-35.72	2.67	45.95

Summary

- Mold detection
  - PLS-1 performed the best among PLS-1, PLS-2, and PCR.
  - Contact probe performed better than the turntable method.
  - The accuracy of prediction improved by adding 3 extra scanning spots with hemp mold detection.
  - By removing outliers, the accuracy of prediction was improved for hemp detection.
  - The accuracy of real-time prediction was slightly lower than prediction from file.

Summary

- Foreign matters detection
  - Some variations of specific weed were fairly high; however, prediction variance of weeds as a group was quite acceptable.
    - The developed NIR method could differentiate weed crops from fiber straw.
    - There is room for improvement to quantify the percentage of each weed crop in foreign crops' mixture.

Summary

- Foreign matters detection
  - By adding scanning spots, the prediction of weeds in flax became more reliable.
  - By removing outliers from calibration, the accuracy of weeds prediction in flax or hemp improved.

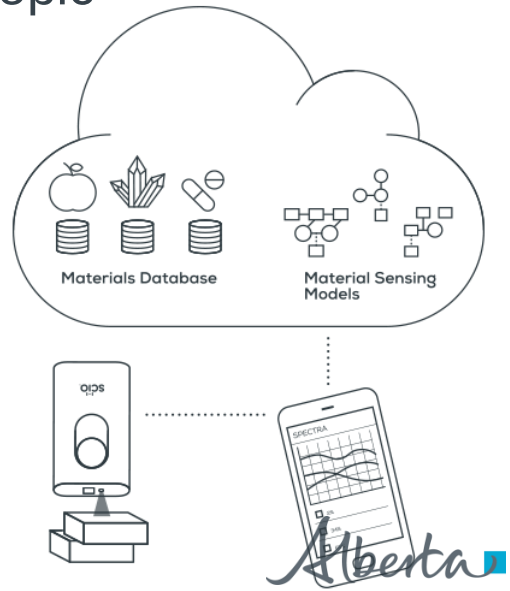
Future work

- More samples: varieties, regions, years, etc.
  - Accuracy
  - Coverage
- To be tested by other NIR spectroscopic devices.
  - Spectral range
  - Software compatibility

Future work

- The concept has been demonstrated to be viable
  - To be validated by handheld NIR spectroscopic devices.






Questions?