Biomass Canada Cluster

Integration/optimization of crop residue production, processing & handling

Principal Investigator: Dr. Shahab Sokhansanj & Dr. Donald L. Smith
Organization: University of British Columbia & McGill University

In Partnership with
Biomass Cluster holder: BioFuelNet Canada

June 2, 2022
Biomass Canada Cluster Webinar Series

Acknowledgement

- Government of Canada under the Canadian Agricultural Partnership
- Biomass Cluster holder: BioFuelNet Canada
- Industry Partners: Barr-Ag Ltd. & Four Peaks

Goal Statement

- The overall objective of Activity 13 is to improve the productivity and efficiency of biomass processing (pre-processing, drying and pelletization) in Canadian commercial farm businesses

- To stay competitive in the regional and international markets, Canadian commercial farm businesses need to optimize their energy intensive operations such as drying and size reduction.

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Project Overview

This project has three components:

- **Component 1**: Develop biostimulants to produce high yields of a range of crop type biomass and, in conjunction with Component 2, test the efficacy of the residue from these crops for potential densification. This includes assessing the effects of the biostimulants on the quality of the biomass

- **Component 2:** Determine applicability including cost/benefit analysis of AI (assisted intelligence) tools to a biomass compaction operation to prove that it is feasible to produce cost effective pellets at the farm level

- **Component 3:** Demonstrate practical densification (150 kg h^{-1}) of wheat straw under production conditions (in collaboration with producer community).

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Evaluate/develop biostimulants to increase biomass yields and key aspects of quality - Component 1

Donald L. Smith

Background

- Growing interest in biostimulants as sustainable way to promote plant growth
- We have worked with a range
- Often microbe-to-plant signals isolated and identified by us
- In many cases help plants to deal with various stresses
  - Often abiotic stresses such as those associated with climate change
- In some cases stress responses can involve changes in plant tissue composition
  - For instance, increased lignification
- Biomass with more lignin might be better used for soil sequestration of carbon or production of biofuels by pyrolysis, rather than through conversion of cellulose to sugars and subsequent fermentation

Objectives

1. Evaluate/develop biostimulants to increase biomass yields and key aspects of quality
2. Determine effects of biostimulant application on biomass quality with regard to biomass densification capacity

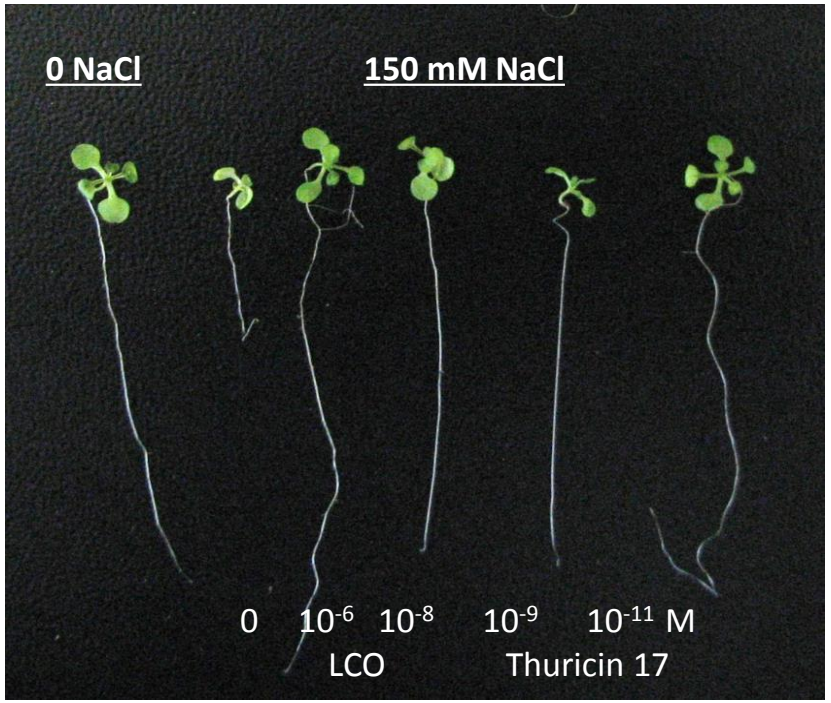
Agroworld

Methods

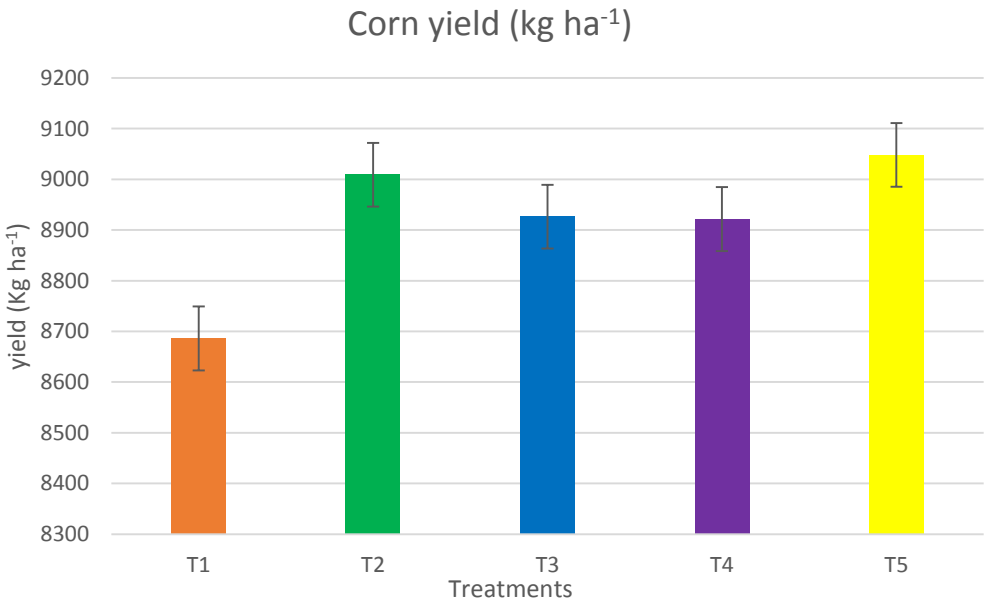
- Set of biostimulants evaluated for ability enhance the crop yields
- Applied as foliar sprays
- Mid vegetative stage
- Foremost Canadian field crops – corn, wheat and canola
- Biomass crop – switch grass
- Horticultural crop – tomato
- Data collected on biomass yield
- Biomass samples sent to UBC for determination of compressibility

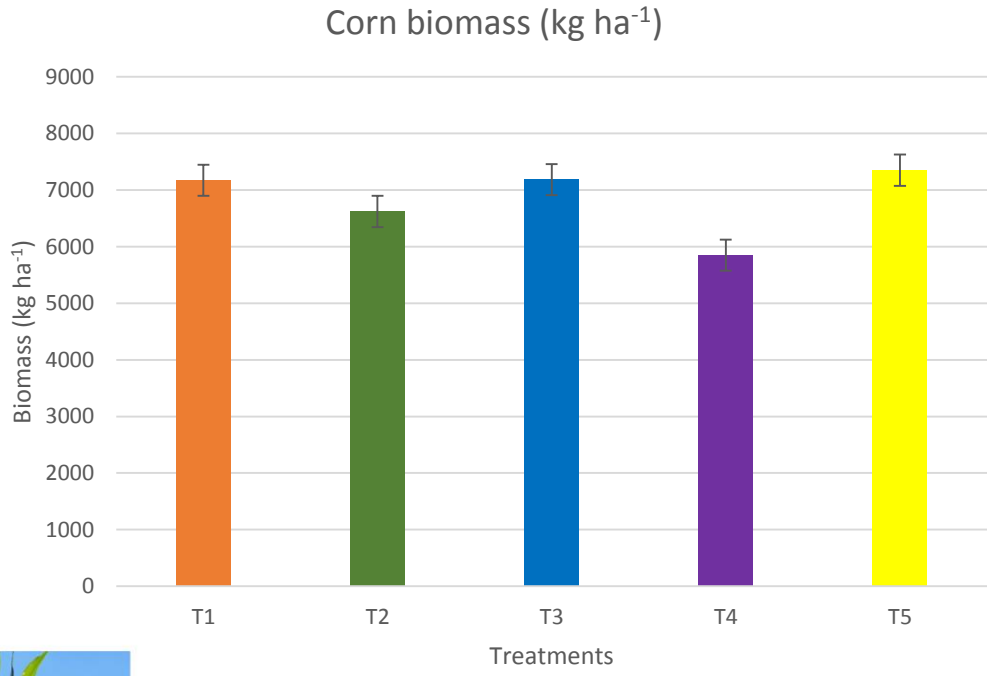
Results - General

- Yield increases often seed due to biostimulants
- Not completely consistent as interacts with environment
- Often much clearer effect when stress present

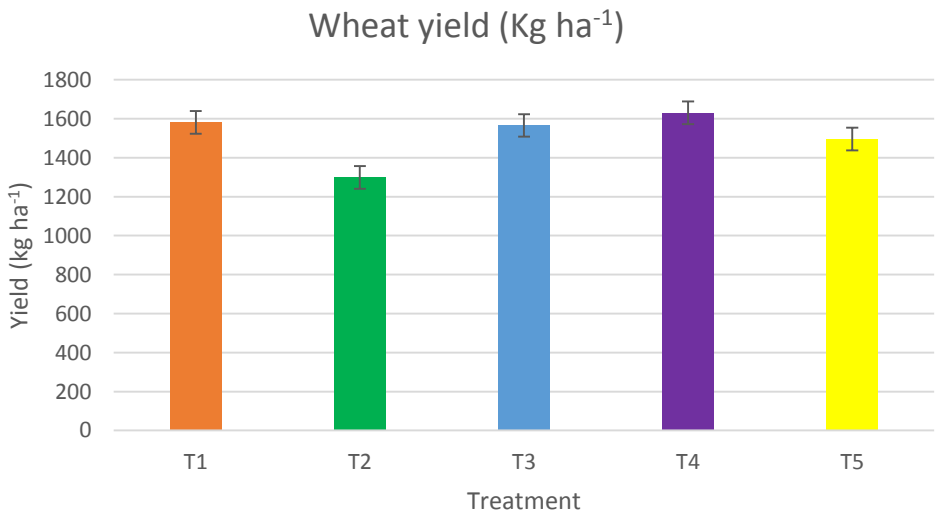


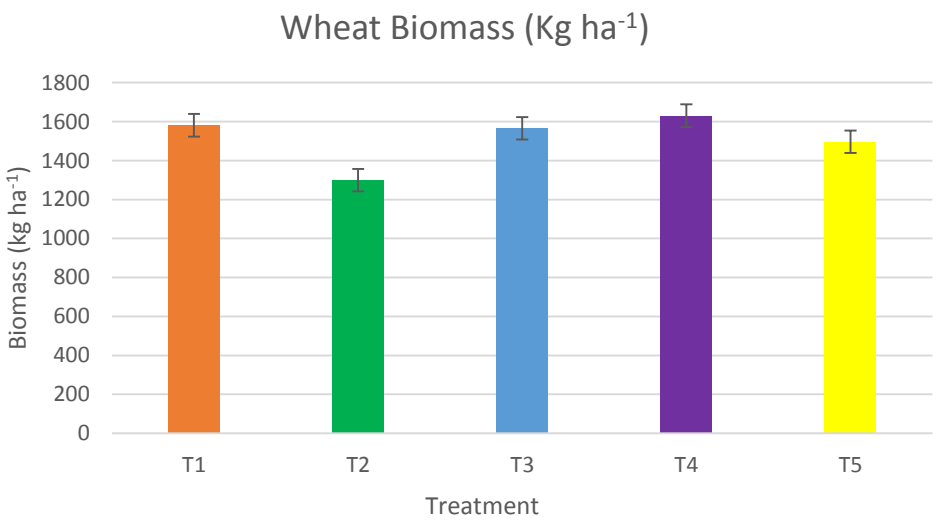
Results - Corn



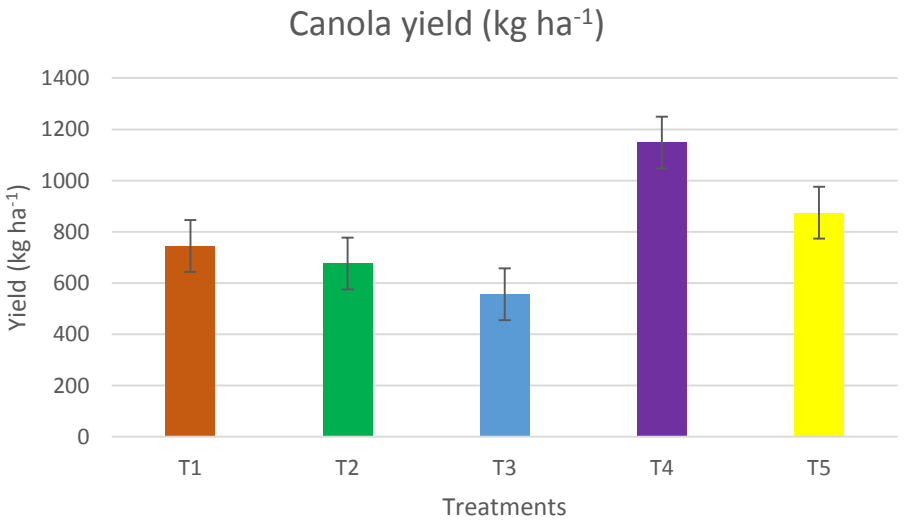


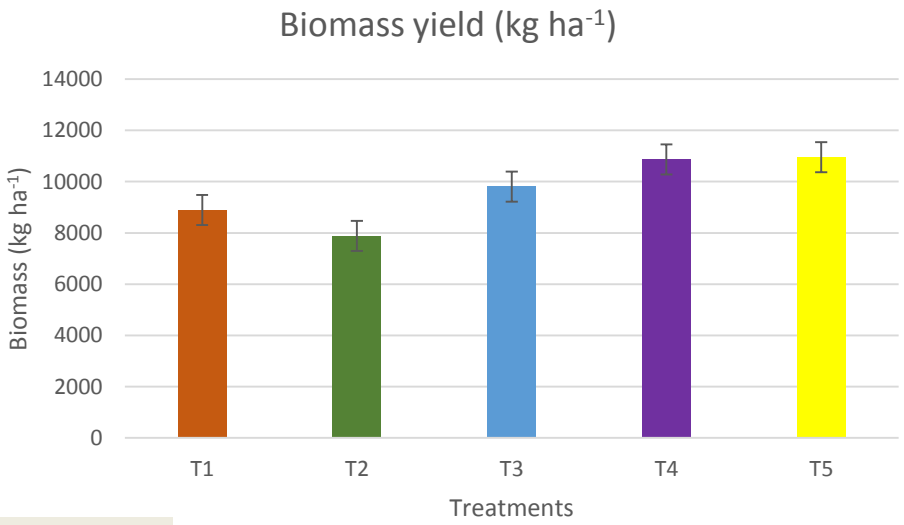
Results - Wheat

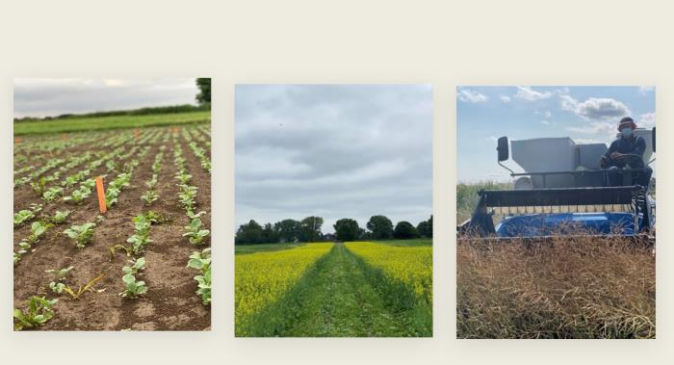




Canola - Yield







Results - Switchgrass

- Increases ranging from relatively modest to 1/2 t ha^{-1}
- Biomass crops would probably be grown on marginal lands to avoid competition with food crops
- Crops grown on marginal lands will be more stressed more often
  - Shallow soils, salt stress, poor texture
- Enough soil C sequestration and improved crop stress tolerance could make some areas move out of the “marginal” classification

Tomato

- Application of flavonoid-based biostimulant caused increases in tomato production
  - fruit size – 8 mm greater diameter
  - fruit number – average of 3 more per plant
  - fruit weight – 300 g plant^{-1} increase
- No increase in biomass

Biomass quality effects

- Biomass (whole crop material for switchgrass, and crop residues for the other plants) have been sent to UBC
- The method has been successfully evaluated on this material and we are now waiting for data on each of the experiments.
- Recently received the first data back on this work, for a single field experiment.
- Overall average of the data points was the largest difference between the control (54.7 KJ Kg^{-1}) and any biostimullant treatment for energy involved in intial processing was only 3.5 %
  - Suggests no major effects in this first bit of data
- Dr. Sokhansanj will explain the processing
  - We are very much collaborating and learning from each other

Next – More Steps in the Supply Chain

- Component 2
- Component 3

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Test the efficacy of the residue from high yield crops for potential densification

Progress Report on Component 1

Dr. Hamid Rezaei

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BBRG BIOMASS.UBC.CA

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Postharvest handling of biomass from McGill cultivars

Seven samples were analyzed: CORN CXC, Soybean, Soybean CXC, Cucumber, Summer Squash, Eggplant, and Tomato.
We ground samples using a Retsch knife mill (4 mm screen opening size). Their moisture content, grinding energy consumption, size distribution after grinding and heating value were measured.

As-received CORN CXC

Retsch knife mill

Ground CORN CXC

Moisture content and calorific value of the biomass received from McGill cultivars

Property	Corn CXC	Cucumber	Soybean	Summer Squash	Eggplant	Soybean CXC	Tomato
Calorific value, d.b. MJ/kg	18.2	15.8	17.9	12.8	16.3	18.5	14.7
Moisture content, w.b. %	9.0	10.2	10.6	9.3	9.2	11.0	9.6

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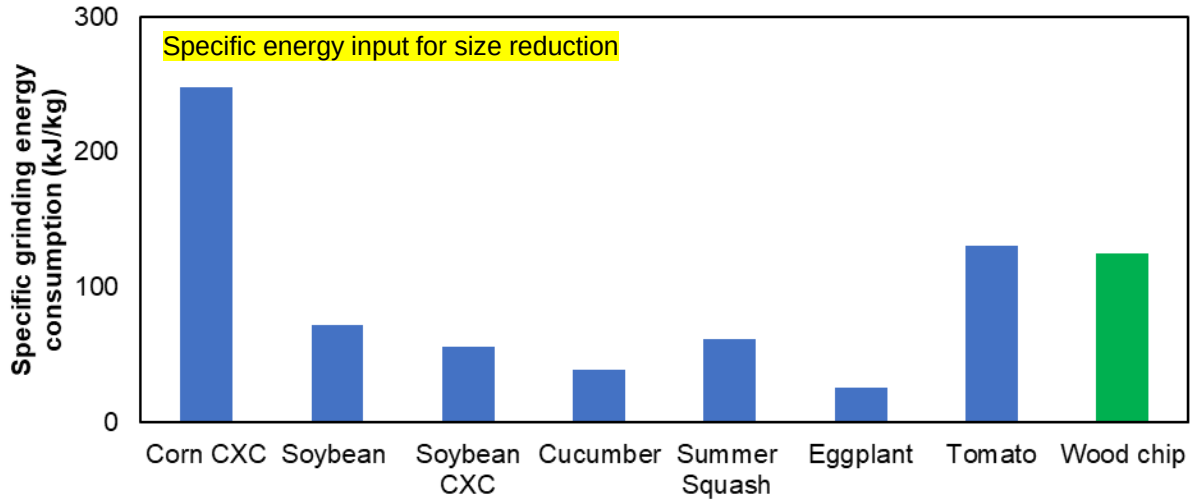
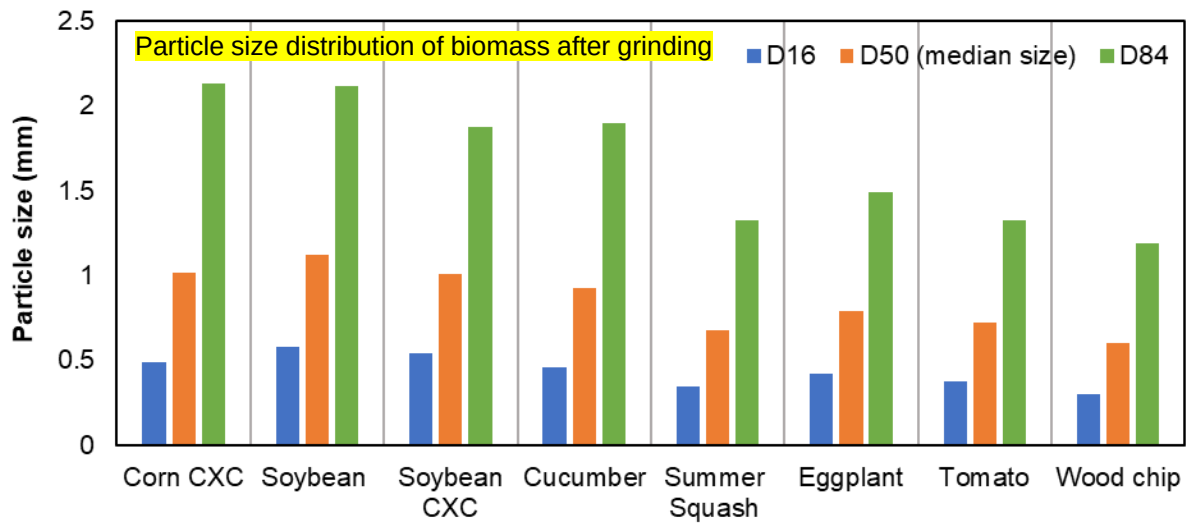
Postharvest handling of biomass from McGill cultivars

- We measured the amperage of the grinder and converted to amount of grinding power consumption.



- We used Standard ASAE S319-4 (2012) to convert raw size reduction data to D16, D50 (median) and D84 parameters.



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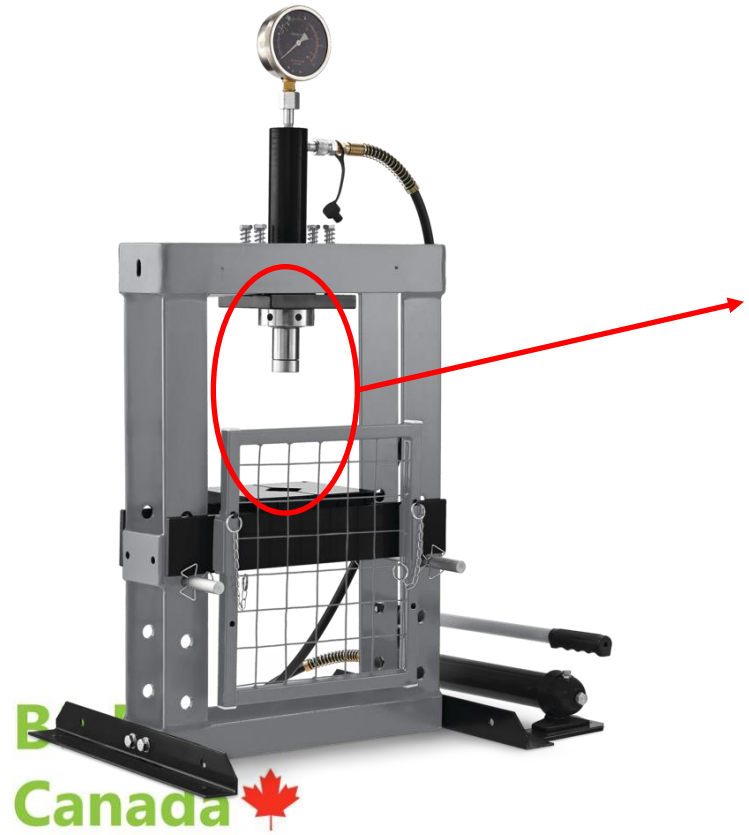
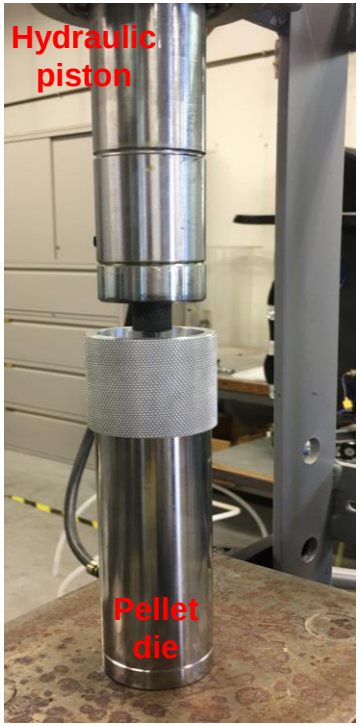
Next Experiments

- We plan to make pellets from the samples (diameter=6 mm and a length≥10mm), using a hydraulic manual press at UBC.
- The press has one piston applying a force of ~5,000 N and a heated die set to compress the material.
- Pellet durability and density will be measured as quality indices.





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Two-step drying technique to reduce GHG emissions, improve output rate, and decrease drying costs: Case study on Barr-Ag Ltd.

Activity 13- Component 2

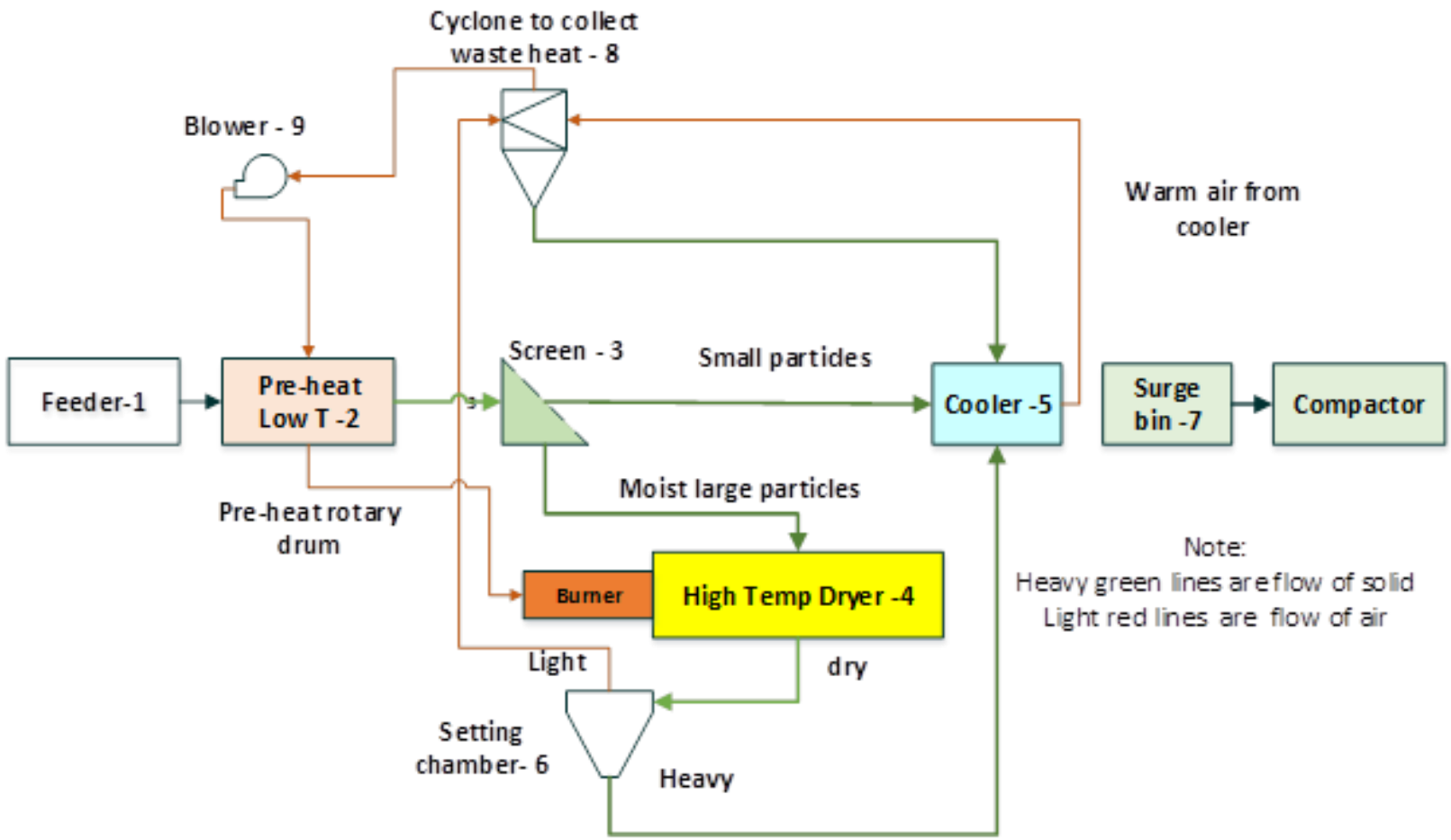
Mohammad Aliahamdi

Barr-Ag Operations

Dehydration and heat treatment unit

Source : http://industriallimones.com/

Design of 2-Step Drying Technique



Modeling for 2-Step Drying Technique

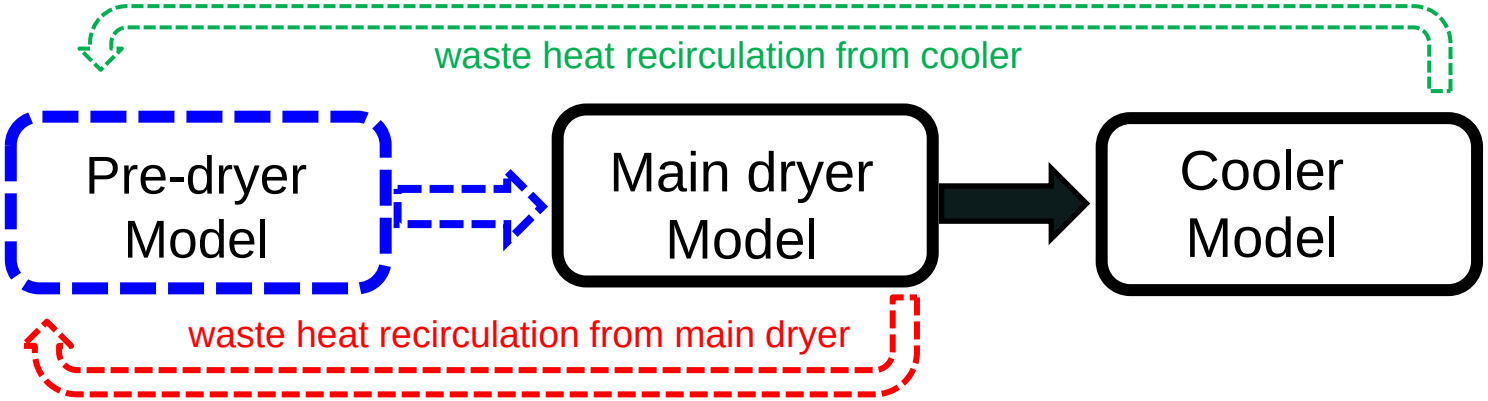
Model development:

- Predict biomass/air properties
- Thermodynamic principals
- Heat and mass balance equations

Proposed scenarios:

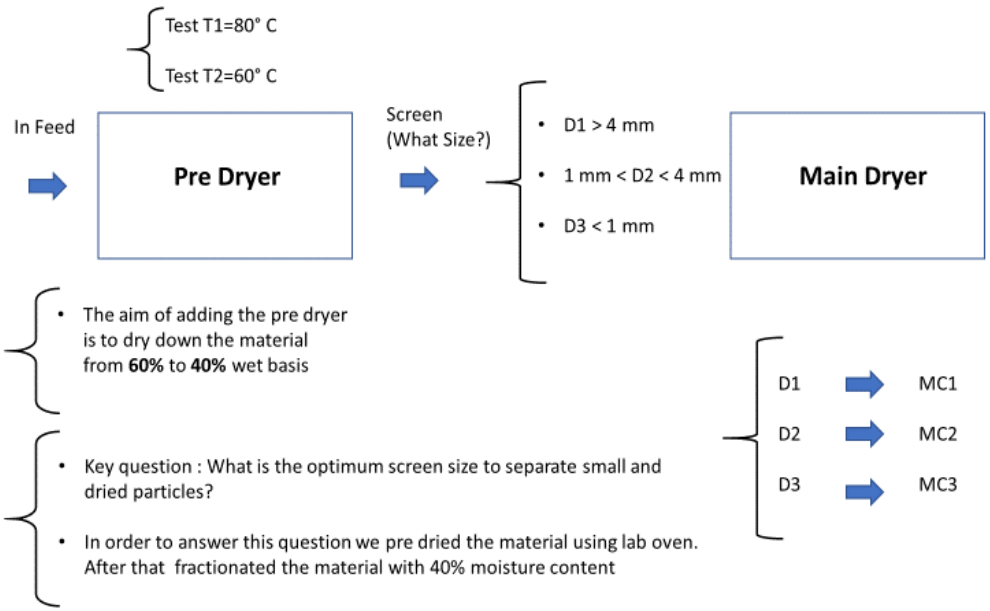
- Case 1: Pre-dryer added, no air recirculation
- Case 2: Cooler exhaust is recycled to pre-dryer
- Case 3: Main dryer exhaust is recirculated to pre-dryer

Energy saving compared to existing system (%)
4%
5%
28%



Screening Properties

The purpose of experiments was to understand the interaction of pre-drying and segregation systems.



- Approximate residence time~ 10 min
- We desire to decrease the inlet MC to ~ 40% consistently
- Intersection with drying rates at various temperatures is highlighted

	As-received, ~63% overall moisture content		Pre-dried, ~40% overall moisture content	
Screen sizes (mm)	Segregation %	Moisture, w.b. %	Segregation %	Moisture, w.b. %
>4 mm	62.81%	64.57%	53.54%	44.04%
1-4 mm	26.61%	61.18%	32.01%	37.25%
<1 mm	10.55%	56.05%	14.45%	32.36%

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Demonstration of mobile ag-pellet unit

Activity 13- Component 3

Mahmood Ebadian

2 June 2022

Demonstration of mobile ag-pellet unit in Didsbury Alberta

Westway Farms Ltd operating a farm business with 7,500 acres of grain and hay along with 500 head of cow-calf operation, looking for diversifying the use of agricultural biomass

UBC-Biomass and Bioenergy Research Group purchased a mobile pellet unit from Sweden with a pellet production capacity of 150 kg/hr. The entire unit fits into a 20’ ft container.

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Progress on the demonstration of mobile ag-pellet unit

- SPC unit arrived at UBC and the CSA inspection was completed in 2021
- BBRG members worked with UBC Plant operations to make all suggested changes to make the pellet machine certified.
- The Pelletization unit (SPC pp150 in a container) was transported from UBC campus in Vancouver to Didsbury in Alberta in February 2022, the location of our farmer partner.
- The farmer has completed the assembly of the pellet unit, setting up the electricity connection and getting the unit CSA certified.
- The farmer is currently putting the pellet mill in its operational location and debugging the unit.

The containerized pellet unit at the farm located in Didsbury, Alberta

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Relevance

- The IBSAL simulation modules for biomass size reduction and dryer help farmers to measure and optimize the energy consumption of their energy intensive size reduction and drying operations
- Design and analysis of an advanced drying system for the Barr-Ag operation
- Understand complexities in setting up an on-farm pelletization system

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Critical Success Factors

- Identify a pre-processing pathway to reduce the energy consumption of drying operation and obtain consistency in the final moisture content of feeds and grains after drying.

- Design a new dehydration system to save energy (cost reduction) and reduce GHG emission up to 30% in our industrial partner's operation

Work to be completed by March 31, 2023

- Develop a model to simulate the whole process starting from material size reduction to final densification process

- Collect industrial data like tonnage, moisture, airflows, gas usage, operating temperatures from Barr-Ag to validate the experimental results

- Calculate the carbon intensity of the biomass processing operations for feeds and grains for Bar-Ag operations

- Work with Wintergreen (FourPeak) to complete the installation of the pellet mill to make pellets from agricultural biomass

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Thank you!

Q&A

donald.smith@mcgill.ca
shahab.sokhansanj@ubc.ca

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