WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

Develop and Evaluate Lignin-Lime Soil Amendment from Wheat Straw Harvesting and Pulping

Bill Pan[1], Wayne Thompson[1], Bill McKean[2], Vicki McCracken[1]
[1]WSU, [2]UW/Sustainable Fiber Technology

Twenty Year Old Program Goal

- Stimulate an integration of the PNW paper and agricultural industries for improving their environmental and economic sustainability.
- Fill data gaps in an ongoing feasibility and engineering study for commercial crop residue pulping trials in eastern Washington.

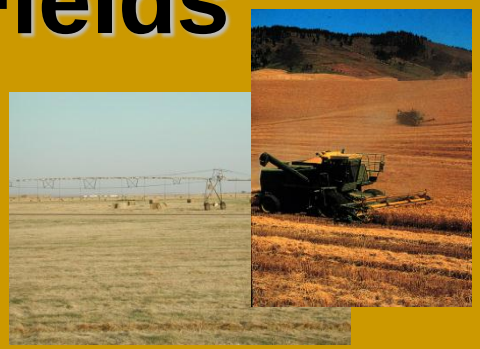
Byproduct disposal, energy or Industrial lignin market

2. Field redistribution of carbon and nutrients

1. Return lignin, lime, carbohydrates ash nutrients "LgLm"

Eroded slopes

Wheat Fields



Productive fields w/ excess straw

Straw

Pulp Mill

Cellulose Fiber

Harvestable Straw while Maintaining SOM Depends on Yield Level

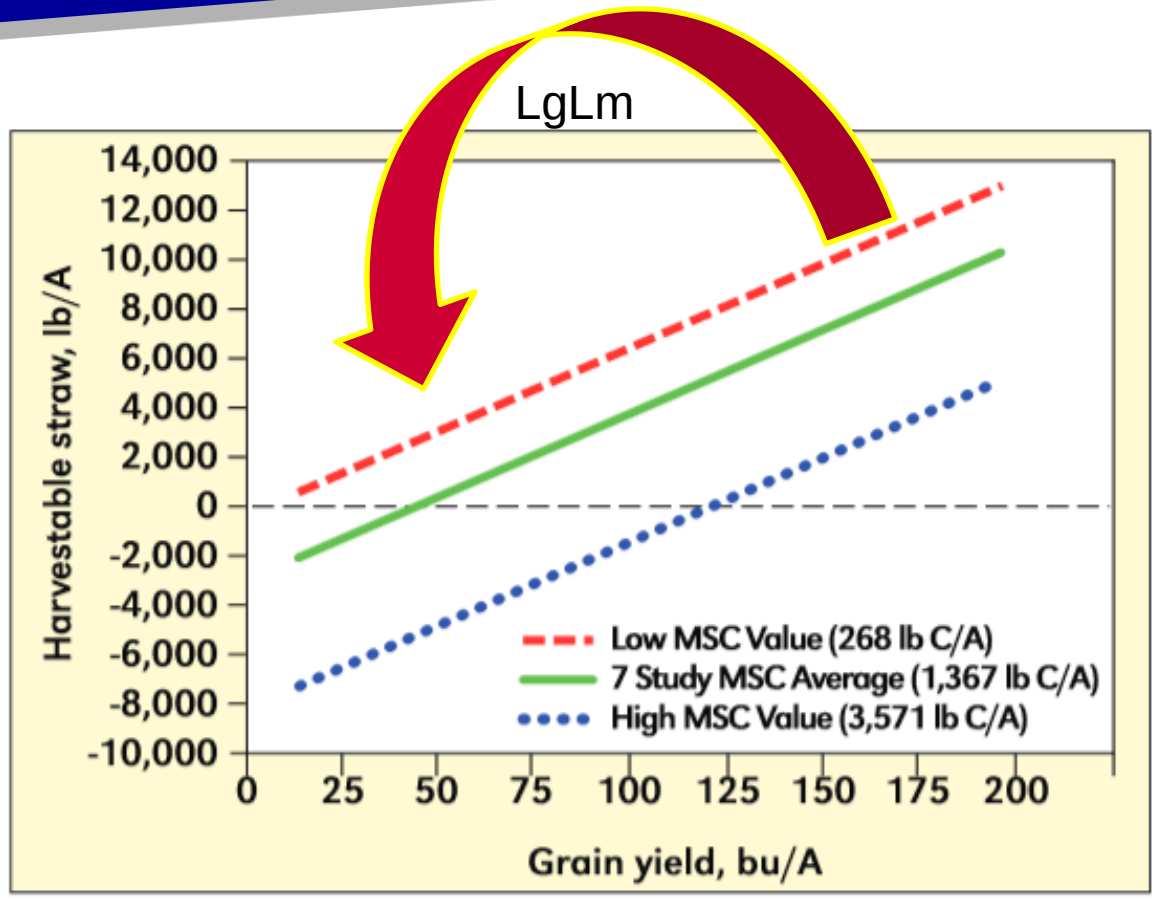


Figure 1. Quantity of annual harvestable wheat straw that maintains SOC (MSC) at a range of grain yields. The solid line represents the average of seven research studies. The dotted and dashed lines represent the upper and lower limits of published information not included in the average line. Specific literature citations used for this study are available from the authors.

Lit review by Tarkelson et al., 2009. Better Crops 93: No. 3.

WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

Straw is a valuable resource

photo by V. McCracken

photo by H. Kok

Table 1. Average nutrient contents in straw per ton of straw*

Crop straw	lb N/ton @$.65/lb	lb P_2O_5/ton @$0.52/lb	lb K_2O/ton @$0.55/lb	Total $/ton
Wheat	13	3.3	23	~$23
Barley	15	4.1	41	~$34

Bill McKean on LgLm viscosities, CP and PPP current status

Research Objectives

1. **Characterize LgLm ability to *increase soil pH and stable soil C.***
2. **Determine whether LgLm improves a) *vertical soil mobility* of lime and b) capability to *complex micronutrients*, potentially increasing their solubility, mobility and availability to plants.**
3. **Assess soil and *field crop responses* of land applied LgLm in direct seed and reduced till systems.**

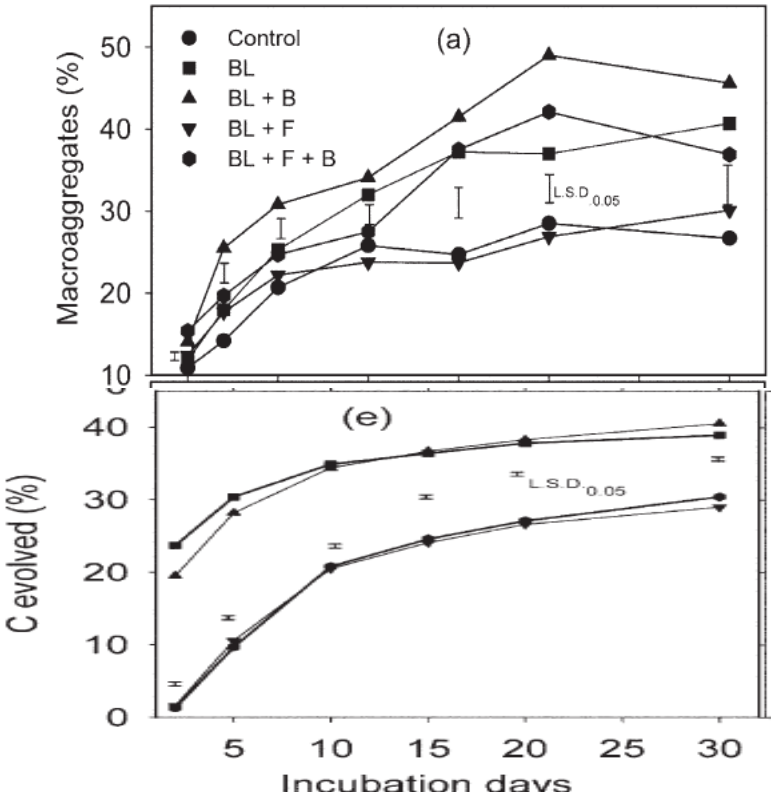
Objectives

4. Put numbers to the Flow Chart: Nutrient and carbon balances, farm economics and agronomics of straw removal and LgLm field applications.
5. Project reports, publications, extension outputs (fact sheets, plot tours, workshops)

WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

Previous Lab Results

- **KOH pulped grass straw byproduct stimulates fungal increase in aggregation; 60% C remains in soil**



Xiao et al., 2008. SSSAJ 72:1472-77.

- **Isolated straw lignin: nearly all C remains in soil**

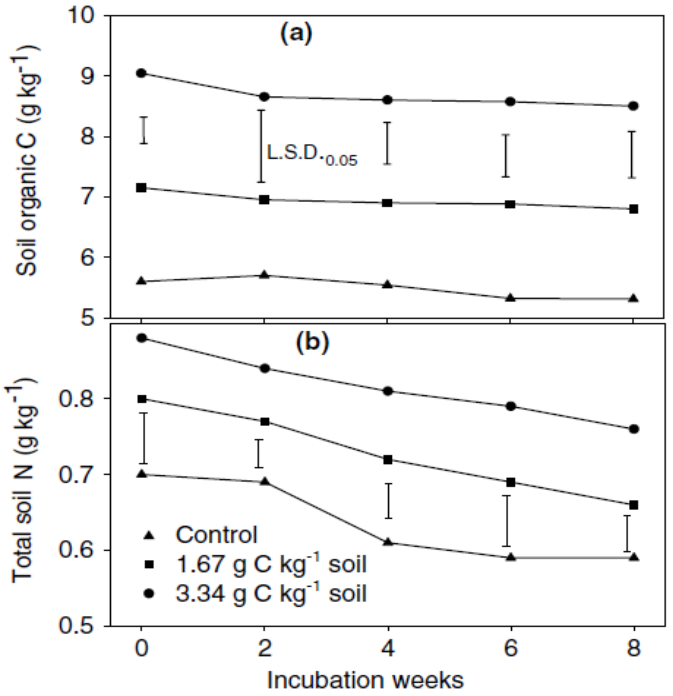


Fig. 2. (a) Soil organic C and (b) total soil N as influenced by lignin derived C rates. I: L.S.D.$_{0.05}$ bars, significant differences among treatments at each sampling date at $p \leqslant 0.05$.

Xiao et al., 2007. Bioresource Tech. 98: 1482-1488.

WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

Methods-LAB

1. Phoenix Pulp and Polymers in Dayton WA will produce pulping by-product at ~15% total solids derived from the alkaline wheat straw pulping.
2. Lab soil studies on various LgLm mixtures
   a. Soil Incubation to test effects over time
   b. Column leaching to test vertical mobility of dispersed LgLm colloids
3. Rhizotron: Root responses to LgLm in acid soils

WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

Soil Column Leaching Type Setup

WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

Rhizotron Capabilities

Day 14

Day 17

Root axis and root hair damage due to ammonia layer above chicken manure.

Canola taproot apical meristem and root hair dieback over xx hours due to encounter with deep placed urea.

WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

Previous Field Results

- **KOH wheat byproduct applied to field soils at Prosser and Paterson without lime additions**
  - **plant K increased, but no effects on corn yields**
  - **Soil pH raised 0.4 to 1.2 pH units**
  - **Microbial biomass and activities increased in surface soils**
  - **Wet soil aggregate stability improved**

Xiao et al., 2006. Biol. Fert. Soils 98: 1482-1488.

WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

Methods-FIELD

- Modify sprayer for viscous liquid delivery
- Field experiments on straw harvested fields:
  - Fall application post-harvest in continuous crop rotations
  - Summer fallow – WW or WC
  - Bee beds?
- 15 x 50 ft georeferenced, replicated plots
- LgLm at 4 rates
- Grower's cropping system
- Sequential soil sampling
- Stand counts, early vigor
- Plot combine harvested
- Root and legume nodule analysis if warranted

WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

Methods-ECONOMICS

- Short term farm economics (farm enterprise budgets)
  - Adjust existing budgets to reflect cost and revenues of:
    - straw removal costs by burning vs. straw harvesting
    - Lg/Lm valuation and application
  - Immediately essential plant nutrients as fertilizers
  - Short term yield impacts
- Long term farm economics (sustainability issues)
  - Shadow prices of essential plant nutrients required as fertilizers in the long term if not replenished
  - Potential improvements in soil productivity

WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

Outputs

- Journal publications (≥2)
- Extension publications (≥2)
- Plot tours, workshops (≥3)
- Inclusion of straw harvest and LgLm Modules into Producer Economic Enterprise Budget

WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

Outcomes

- System-wide solution to field burning that makes straw harvest/direct seed system more sustainable
- Increase SOM
- Neutralize soil pH of acid soils
- Improve overall nutrient availability

WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

Budget

- **Preliminary preparation and research: summer 2015.**
  - **PPP: supplies, travel: $10,000**
  - **PPP: labor/supplies to generate LgLm**
  - **WSU/USDA REACCH salaries: ~$10,000**

WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

Main Project Budget

Sept 2015-Aug 2017

- **DOE: $140,000**
- **WSU: $100,000**
- **PPP: labor/supplies to make LgLm**

WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

DOE 2 yr Project Budget

- ½ time MS student, 1 FT, 1 PT student: $89,991
- Supplies: $5,000
- Travel: $6000
- Indirect Costs: $38,695
- TOTAL: $139,686