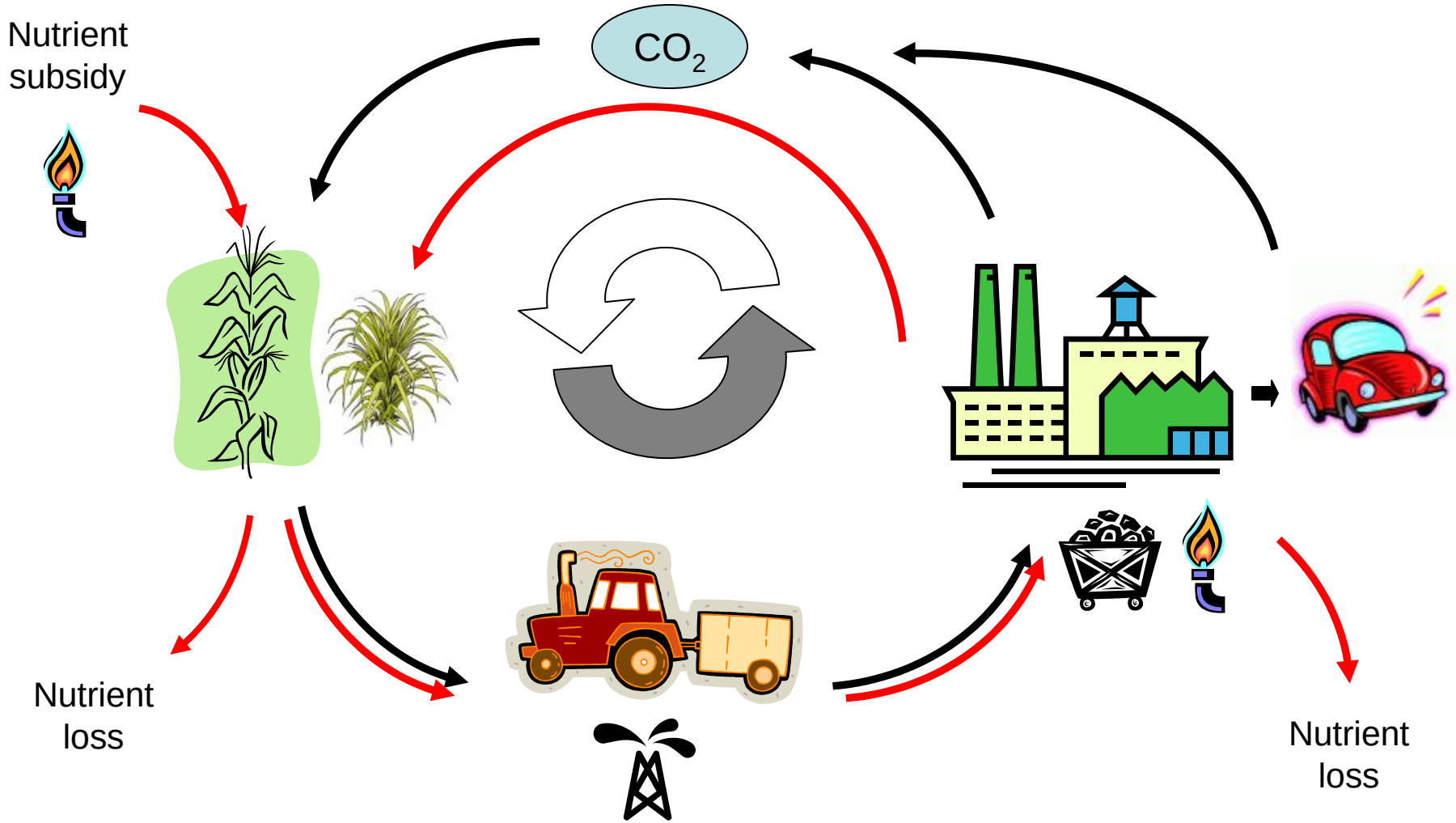
IOWA STATE UNIVERSITY
Department of Agricultural and Biosystems Engineering

Pelletizing Biomass Ash for Fertilizer

Katherine Edwards
Graduate Research Assistant

Dr. Robert Anex
Associate Professor
Iowa State University

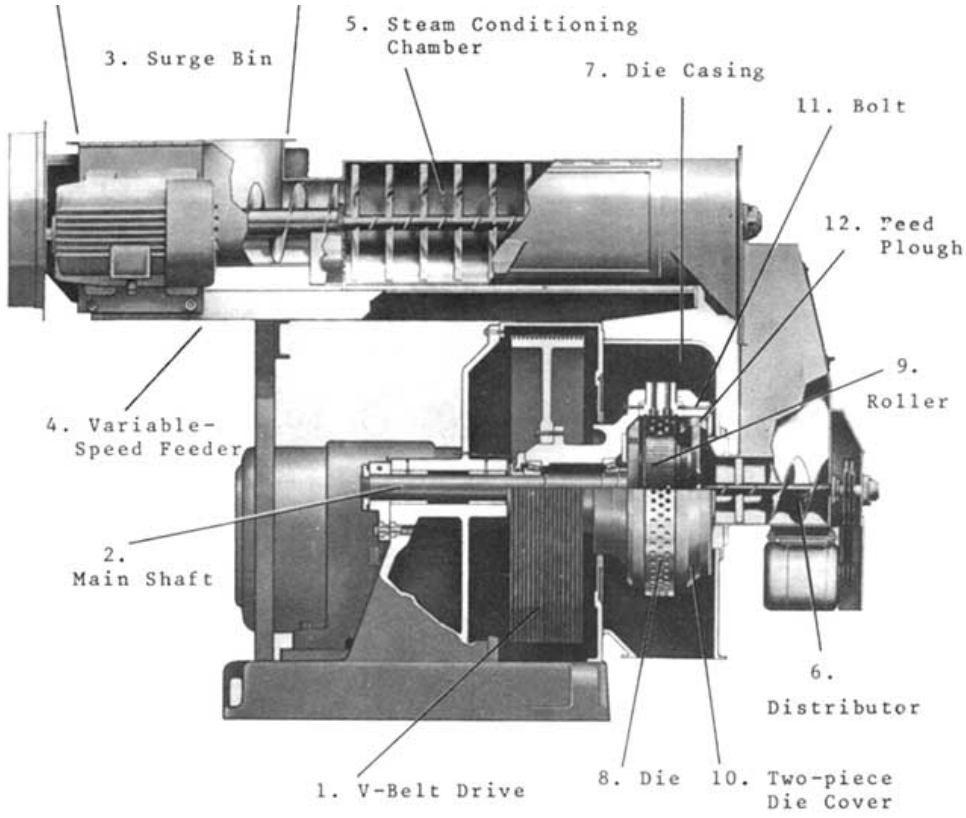
Closed Carbon Cycle but Open Nutrient (N,P,K) Cycles



Ash Pelletization

8,000 dry tons of ash would be produced from a 50 MMG/yr Ethanol Plant powered by gasifying corn stover.

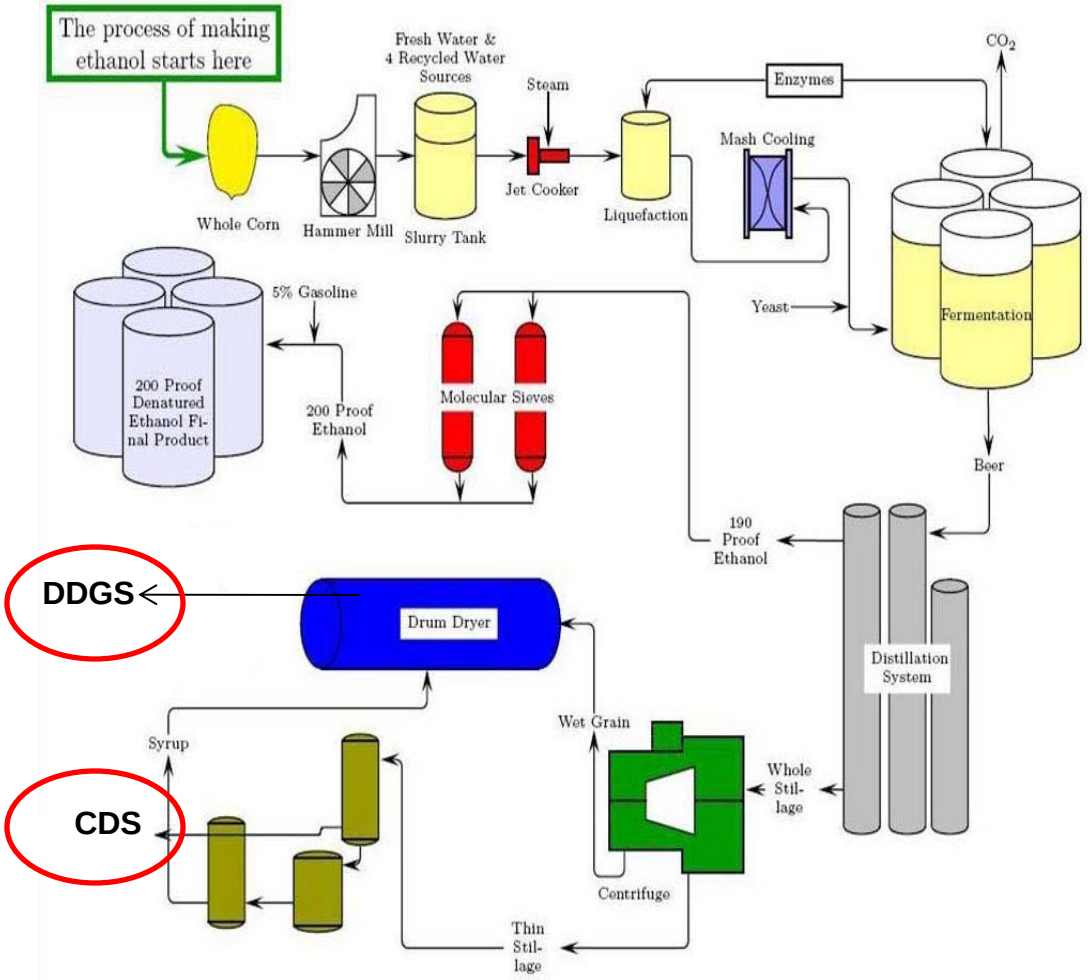
Feed Pellet Mill



Binders

Biotechnology Byproducts

Ash Origin:
Combusted CDS



Experimental Design

Feed Pellet Mill

Binder Type: CDS, Bonemeal, DDGS

Binder Level (%): 3 levels

Moisture Content (%): 3 levels

Predictive

Face Centered Response Surface Design

Explanatory

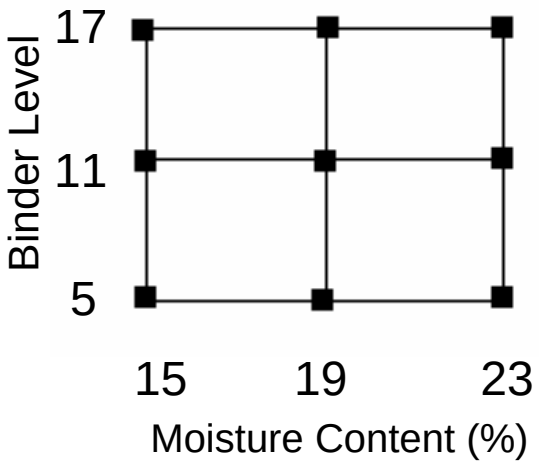
2 Way factorial ANOVA
blocked by binder type
Test for effects binder level, binder, and moisture content

Response variables (Physical and Chemical Properties):

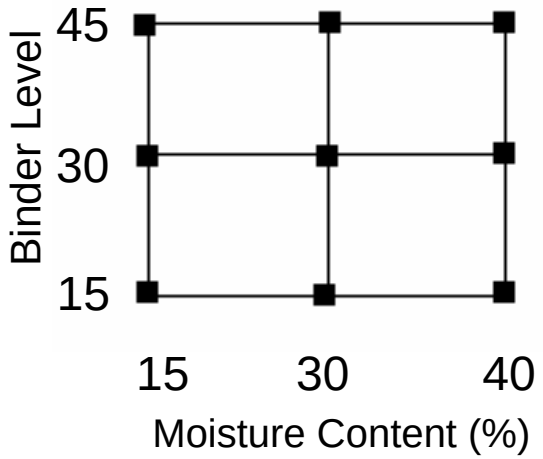
- Durability, degradability
- Total (N,P,K, C) and water soluble (N,P,K), pH, liming capacity

Face Centered Response Surface Design

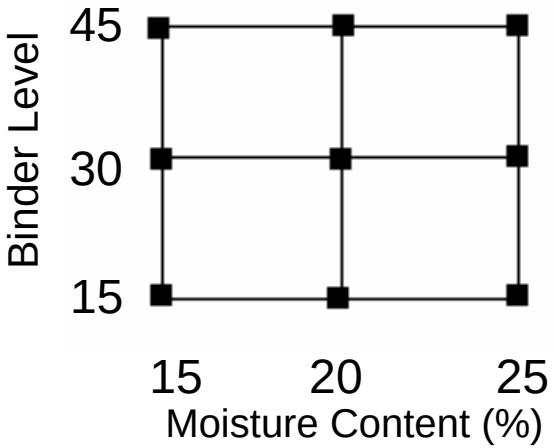
Condensed Distillers Solubles



Dried Distillers Grains with Solubles



Bonemeal



Pelletization

Ash

Binder

DDGS

California Pellet Mill: Model CL5

Response Variable Testing

Total nutrients:
N and C - Lieko combustion analysis
P and K - Acid Digestion and ICP

Water soluble nutrients: Aqueous solution analyzed with ICP

Durability Test: ASABE standard

Liming Equivalence: Effective Calcium Carbonate Equivalent (ECCE)
AOAC 924.01

Degradability: Water sieve analysis, component of ECCE test

Results: 2-Way ANOVA p-values

Response	Binder	Binder Level	Moisture Content	BL*MC
Durability	<.0001	0.0169	0.0997	0.4993
pH	0.0013	0.0952	0.0606	0.7659
ECCE- Lime equivalence	<.0001	0.0120	0.1442	0.5228
4-Mesh	<.0001	0.0011	0.0481	0.0958
8-Mesh	<.0001	0.0008	0.1246	0.3529
50-Mesh	<.0001	0.0051	0.3659	0.5838
Total C	<.0001	<.0001	0.9849	0.9624
Total N	<.0001	<.0001	0.9763	0.9888

Water Degradability

* Significance p<0.10

Mean binder response: 2way ANOVA

Tests	Bonemeal	Condensed Distillers Solubles	Dried Distillers Grains with Solubles
Durability (%)	80.52 (a)	18.24 (C)	51.66 (b)
pH	10.79 (b)	11.78 (a)	11.13 (b)
ECCE- Lime equivalence	115.01 (b)	441.84 (a)	321.17 (a)
4-Mesh (% pass through)	31.10 (b)	85.14 (a)	86.10 (a)
8-Mesh (% pass through)	20.75 (b)	82.62 (a)	80.66 (a)
ugh)	18.62 (b)	63.16 (a)	48.84 (a)
	8.17 (b)		
	0.88 (b)		

Water Degradability

Bonemeal – higher durability
DDGS – higher degradability

CDS did not create a viable pellet because durability is below commercial pellet values

Predictive Models

Response Surface Designs

Fit of 2nd order response surface predictive model

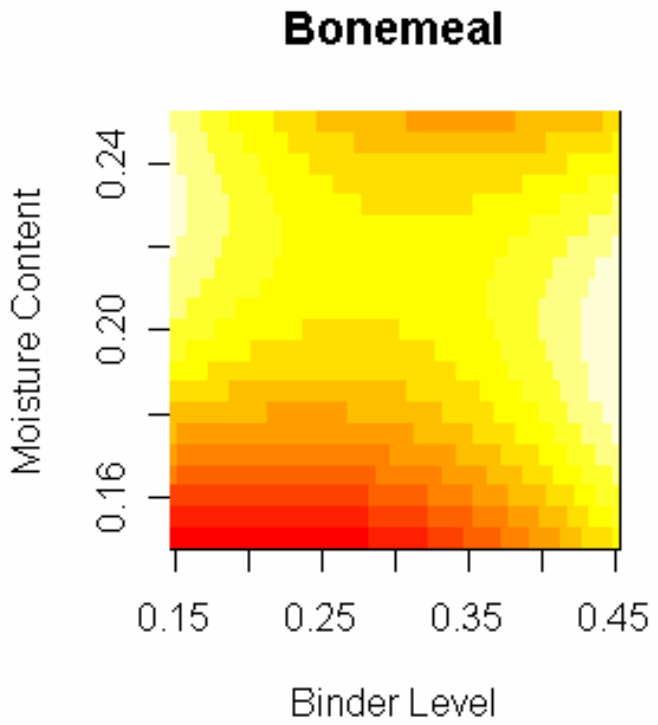
Response	Bonemeal	CDS	DDGS
Durability			
pH			
Liming equivalency (ECCE)			
Fourmesh			
Eightmesh			
Fiftymesh			
Total Carbon			
Total N			

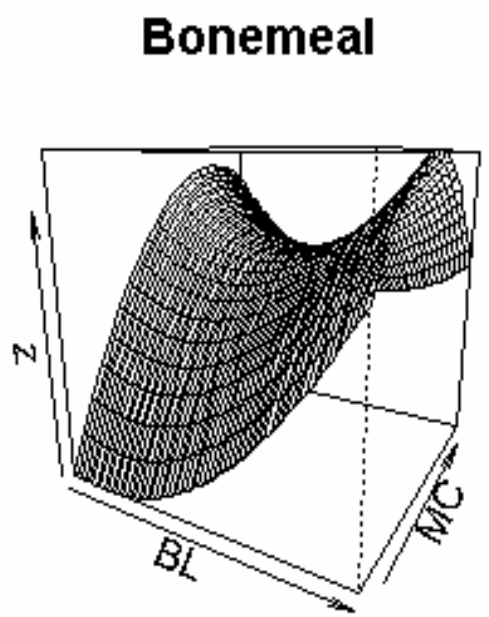
Water Degradability

pvalue<0.1

pvalue > 0.1

Bonemeal Durability





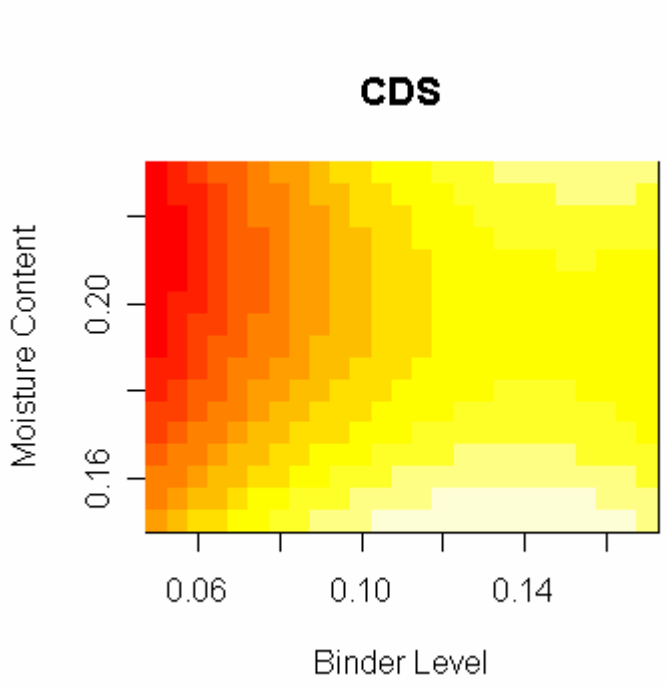
p-value: 0.008934
R-squared: 0.9203

Opposing Trends

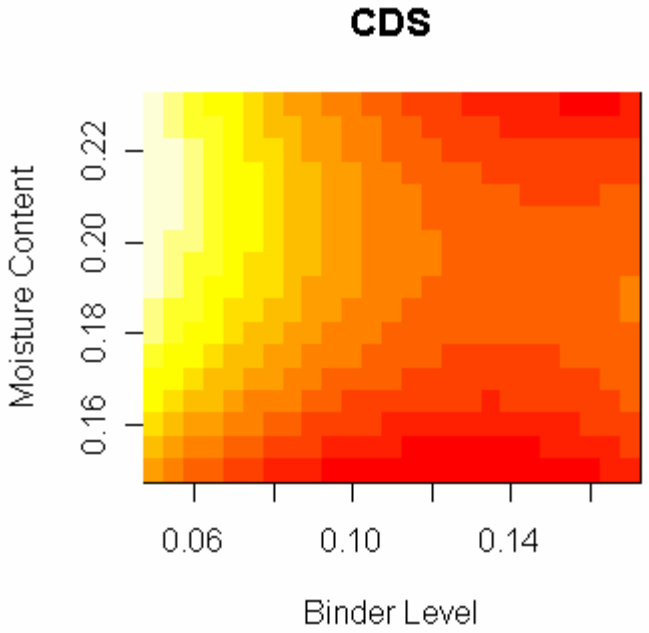
Liming Capacity and Durability

ECCE dependent on water degradability

Liming Capacity (ECCE)

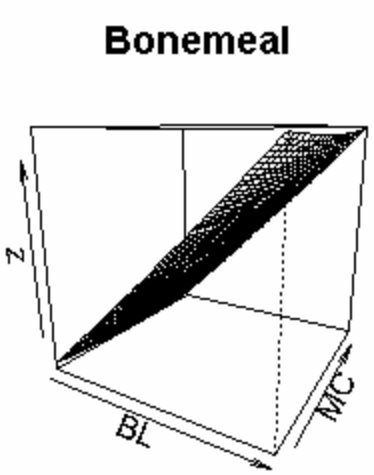


Durability

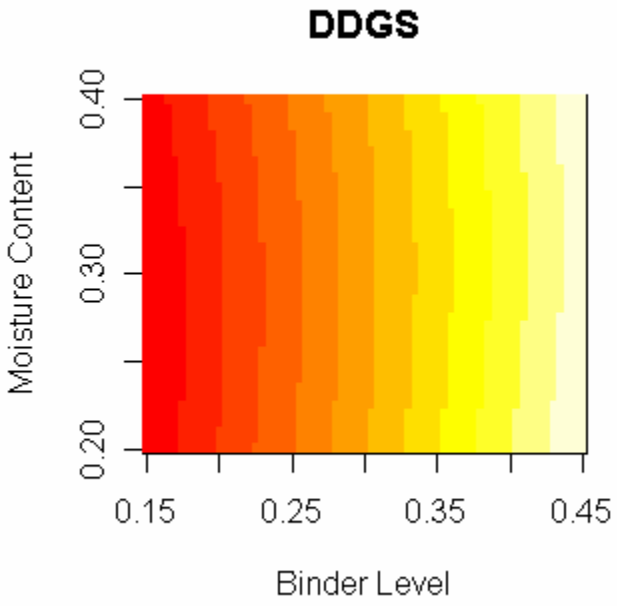


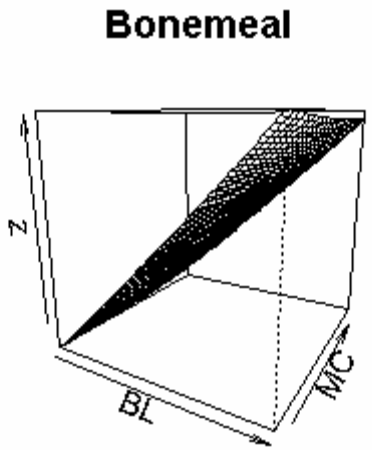
Nutrients

Increase with binder level



Nitrogen





Carbon

Conclusions

- Biomass ash can be pelletized using multiple binders
- Binder type and binder level significantly effect pellets physical and chemical properties
- Increasing durability tends to decrease the water degradability of the pellets
- CDS is not recommended for use as a binder due to extremely low durability

Acknowledgements

Anex/Raman lab group

Tate and Lyle Ingredients Americas, Inc.

Dr. Carl Bern, ISU Biomaterials Research Lab

This material is based upon work supported by the National Science Foundation under Grant No. 0424700

ISU Center for Crop Utilization Research