Welcome to 2023 Kernza Con!

JUNE 22 – 23, 2023

Photo Credit: Prabin Bajgain

Introduction to Interactive Equity Activity

KERNZA® CONFERENCE 2023: EQUITY ACTIVITY

Inequities & work toward equity

- **Inequities:** Disadvantages and exclusion for some groups, and at the same time, advantages for other groups. Inequities are created and sustained through practices, policies, and systems over time.

- **Equity work:** Process of identifying how to reduce, correct for, and repair these imbalances in access - and making the changes to do so - with aims to achieve greater fairness and flourishing for everyone.

Racial equity focus

- Systemic racism and settler colonialism have deeply shaped who has access to land, capital, farming, agricultural institutions, and the economy in the US.
    - Example of racial inequity: acres of Black-owned farmland declined from ~14-16 million in 1920 to 2 million in 2000 (Penniman 2018; Shostak 2021)

- All forms of social difference - such as gender and sexual orientation, nationality, age, ability, geography, and economic and educational background - also shape grain agriculture, R&D, and supply chains.

- We encourage you to think in broad and intersecting ways about inequities and equity.

Last year’s conference attendees generated responses to these three prompts… let’s build upon that.

PROMPT 3: A CONCRETE ACTION THE KERNZA NETWORK CAN PURSUE COLLECTIVELY TO ADVANCE EQUITY IS...

Responses fit into four main categories:

Redistributing material resources and de-risking supply chains

Changing internal and reflexive practices within the network

Changing who enters into the network

Relationship-building & Co-creation of priorities, grants, and supply chains

Equity activity 2023:
Prompt 1, reflect & submit response anonymously

Have you taken an action to help make the network more equitable since last year? *[see Prompt 3 printout]*

- **If yes**, write down the type of action. What worked well? What challenges did you face?

- **If no**, what specifically makes you hesitate? If you thought about an action or tried, can you identify something specific that got in the way?

Equity activity 2023:
Prompt 2, share on board

Now is the time to prepare for the next big investments in Kernza.

- **How would you approach or design future Kernza projects and/or funding opportunities with equity and inclusion in mind?**

Equity activity recap: Tasks for today

1. **Submit your reflection for Prompt 1 anonymously in the folder**

   There are index cards and pens next to the folder

1. **Write your ideas for Prompt 2 on the paper for the group to interact with**

Do both before the final breakout session at 4:00. This activity is open for everyone!

Join the breakout session at 4:00 pm if you'd like to reflect more on these prompts.

Lightning Talks #1

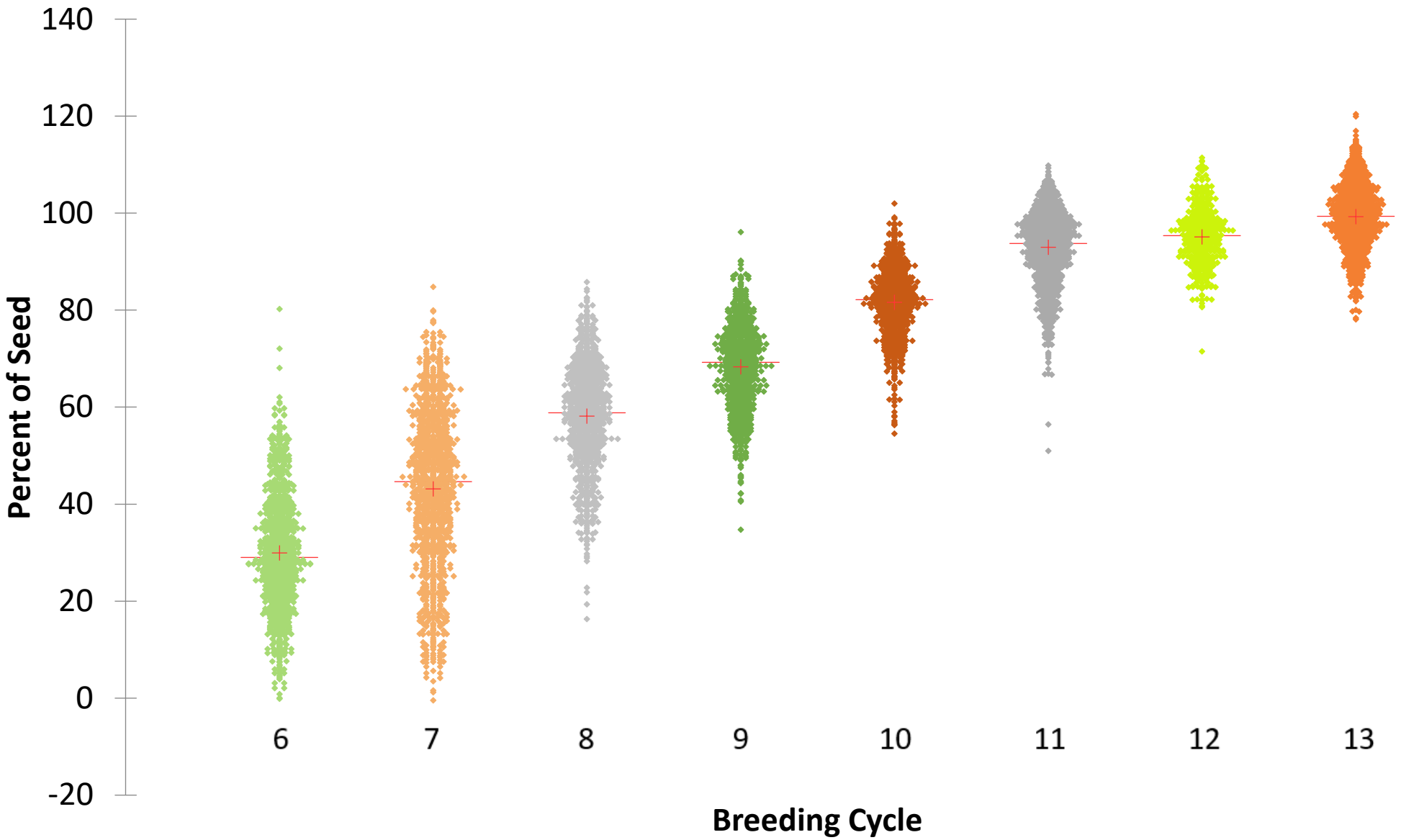
Conventional Selection

Kernza
Breeding

Lee DeHaan

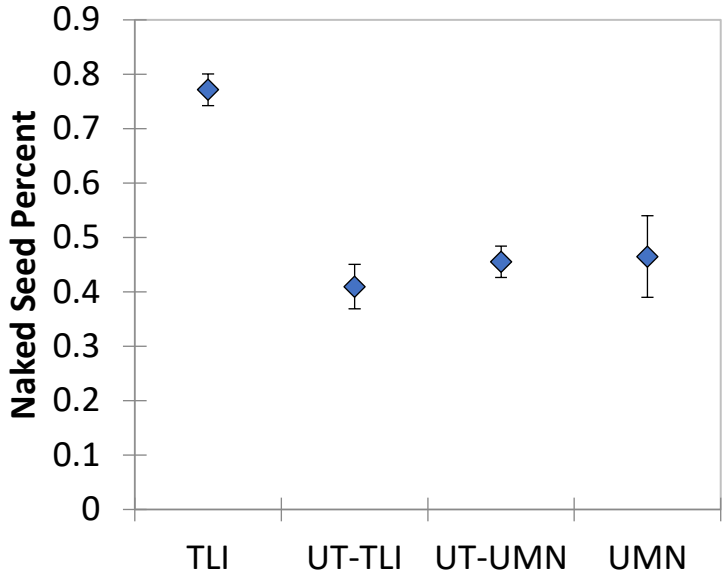
Genomic Selection

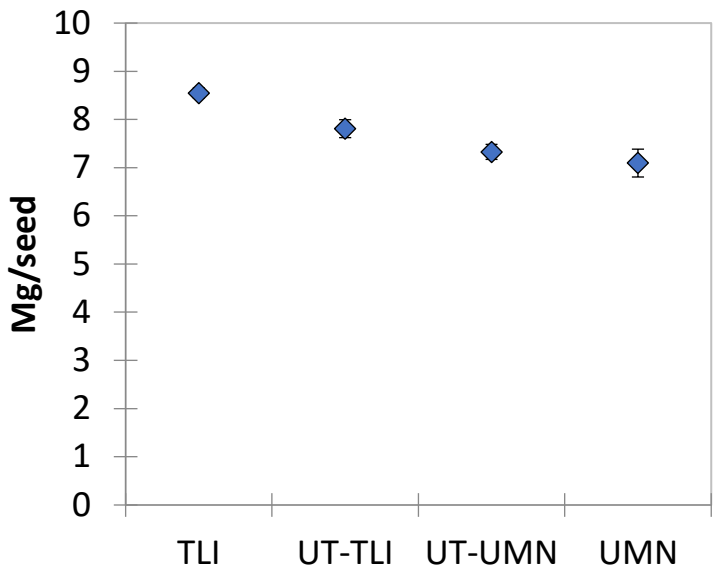
Genomic Breeding Values of Free Threshing Percent

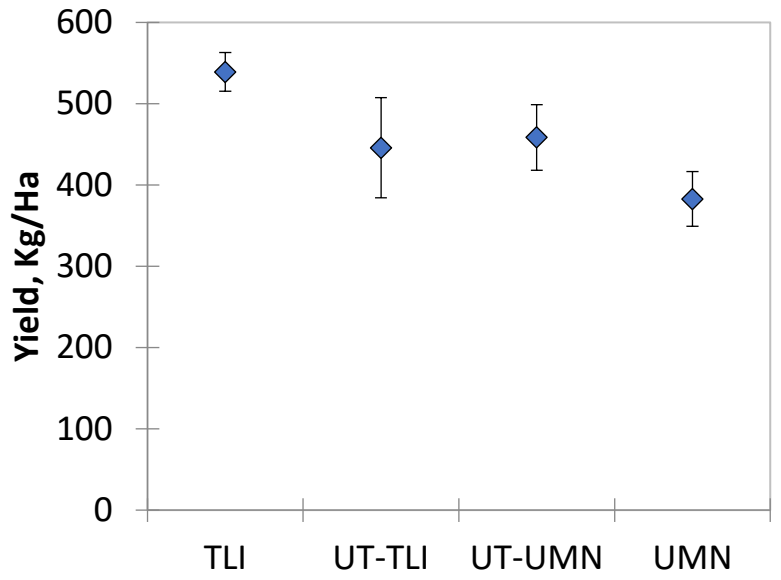


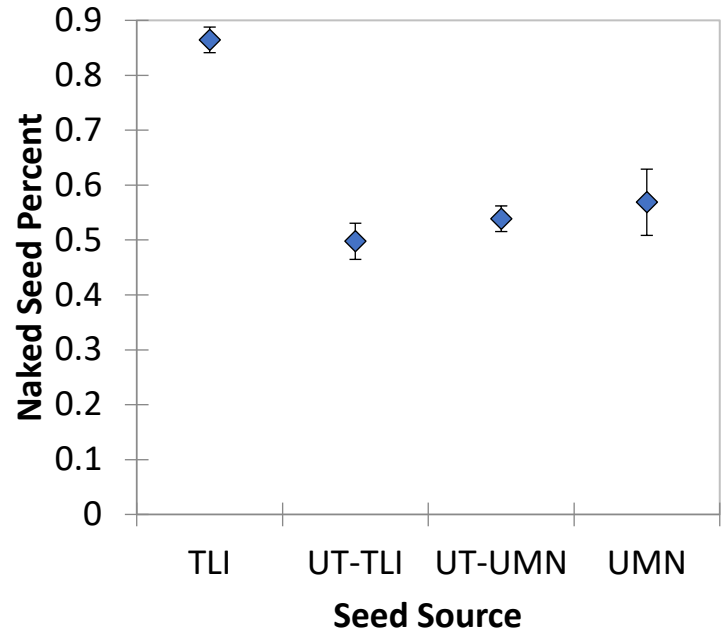
Mild Year (2021)

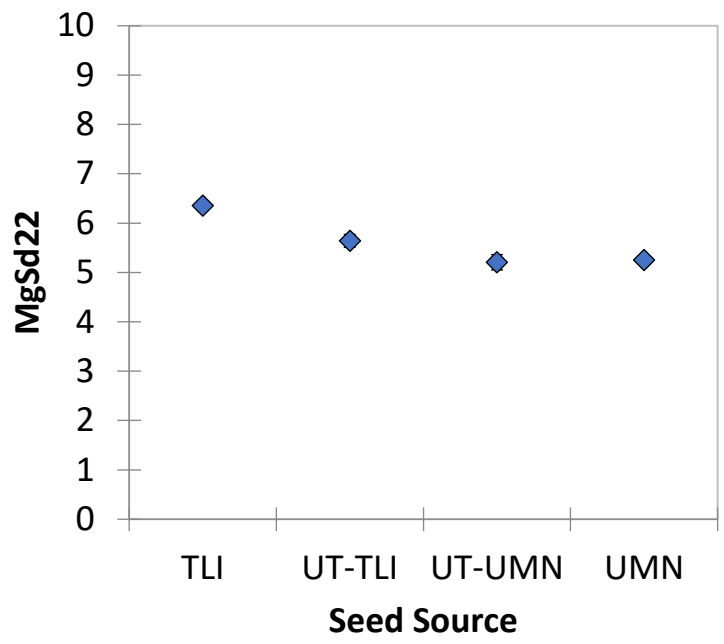
Drought Year (2022)

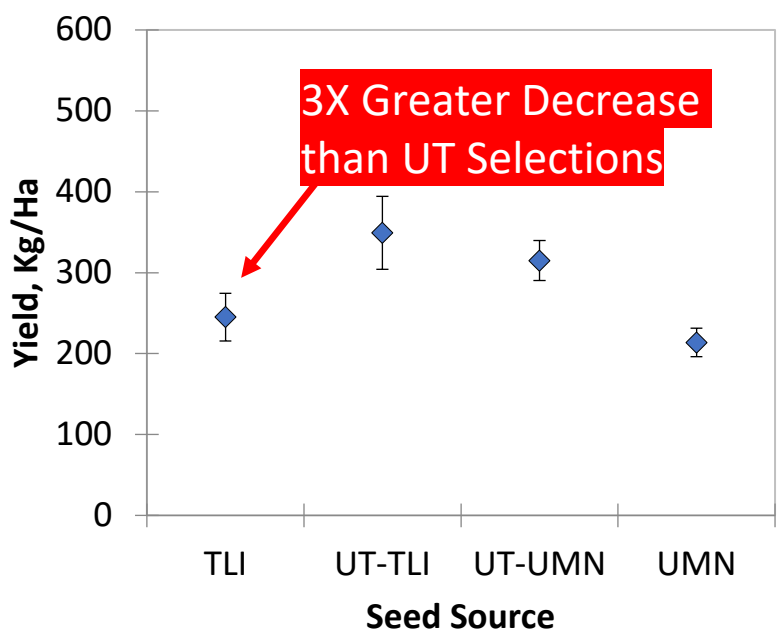












Conclusions

- We need multiple breeding programs targeting diverse environments
- Sharing germplasm between programs can have mutual benefit
- Genomic selection allows a rapid pivot toward new breeding goals
- We aim to have varieties with greatly improved drought tolerance within three to five years

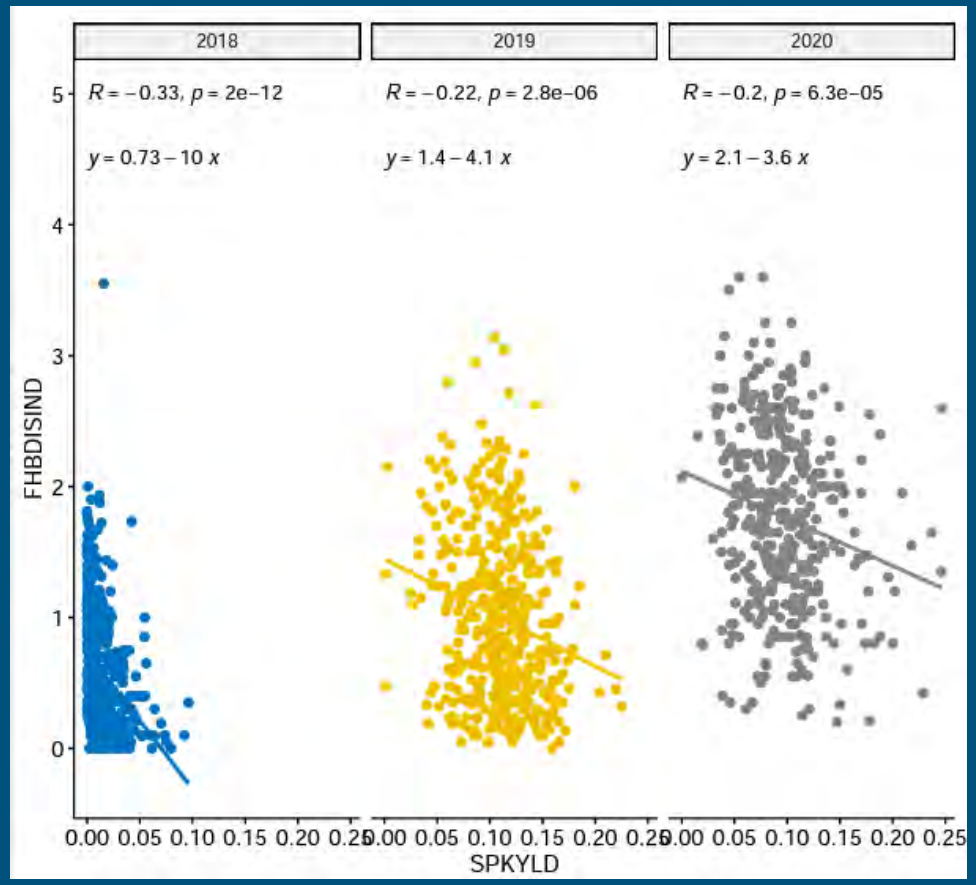
Update on diseases of intermediate wheatgrass

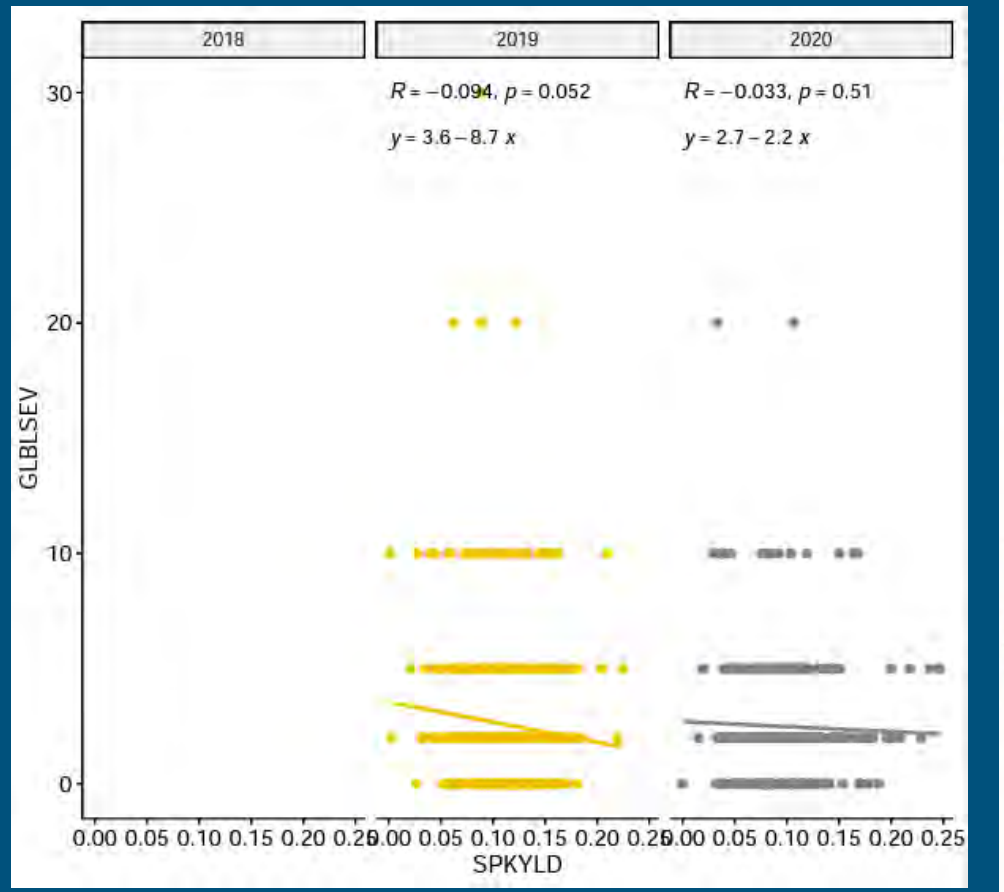
Kathryn Turner, Yvonne Thompson, Leah Treffer, Anusha Dahal [†], Angela Brekalo

The Land Institute Crop Protection Genetics,

[†]Dep. Plant Pathology, Kansas State University,

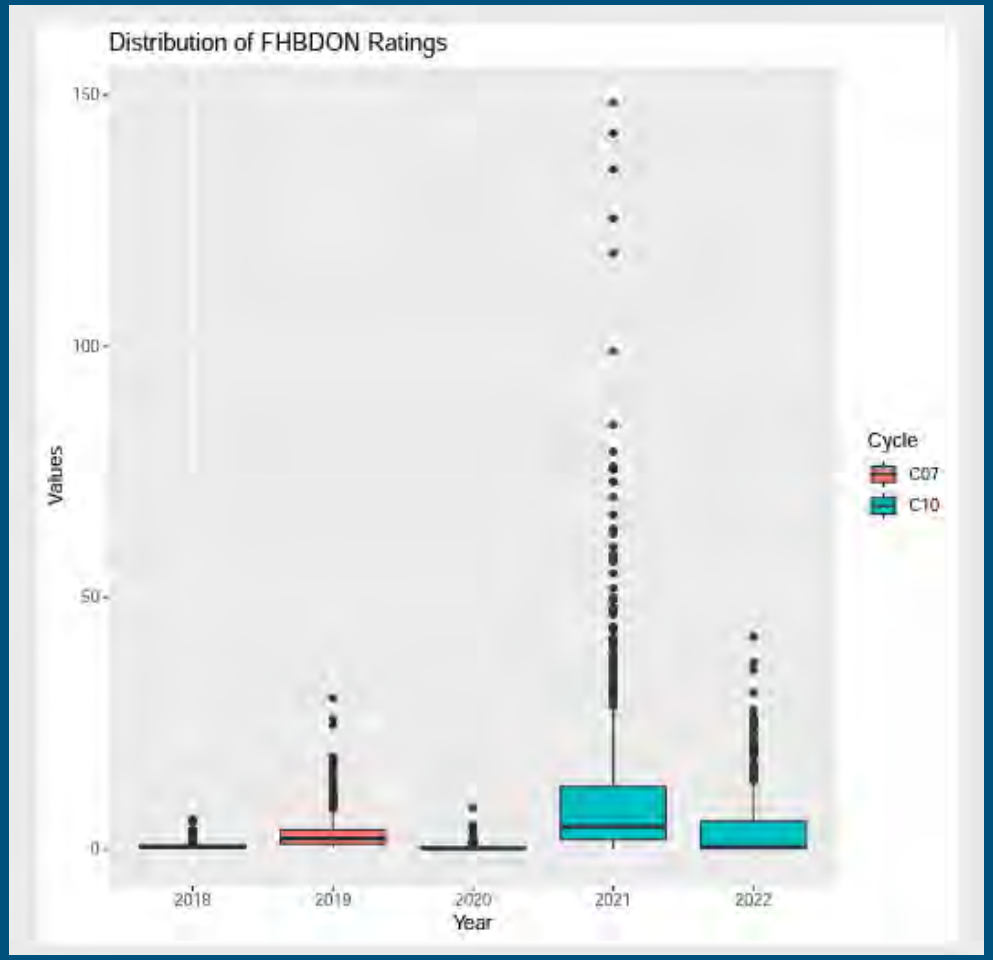
Grain yield related to head diseases

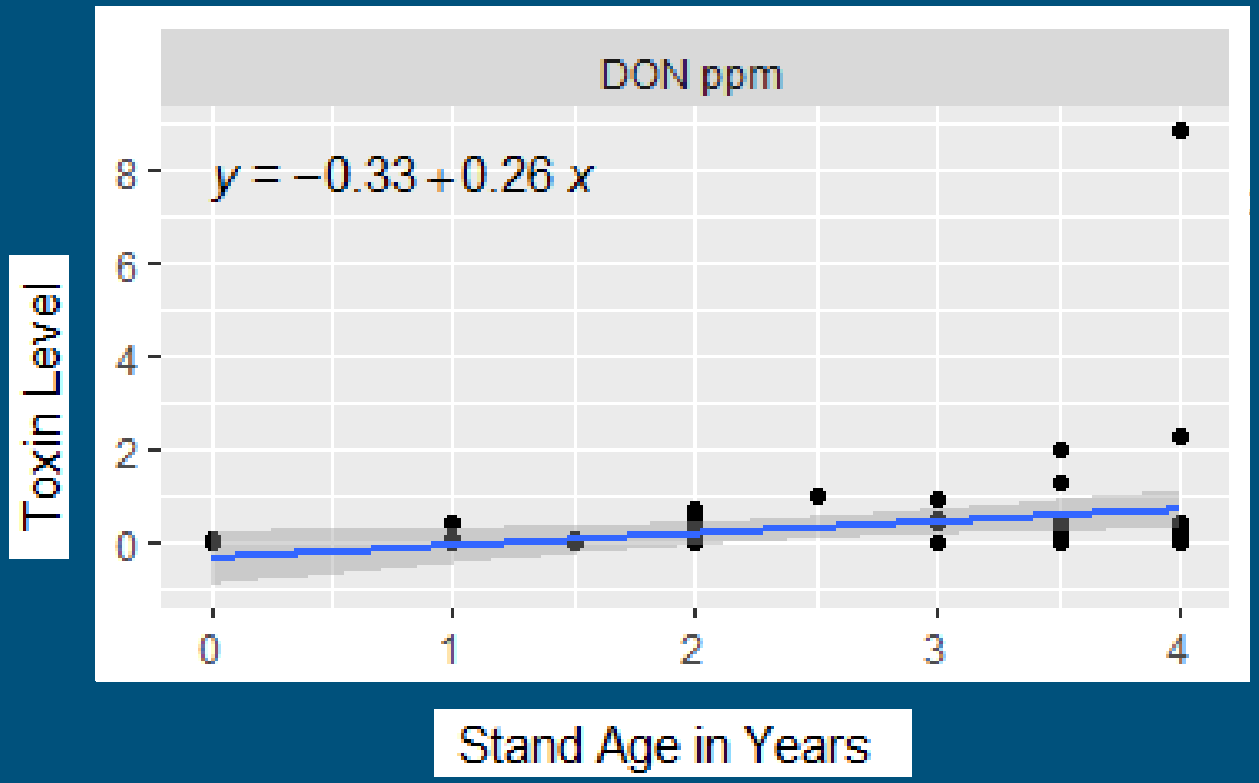




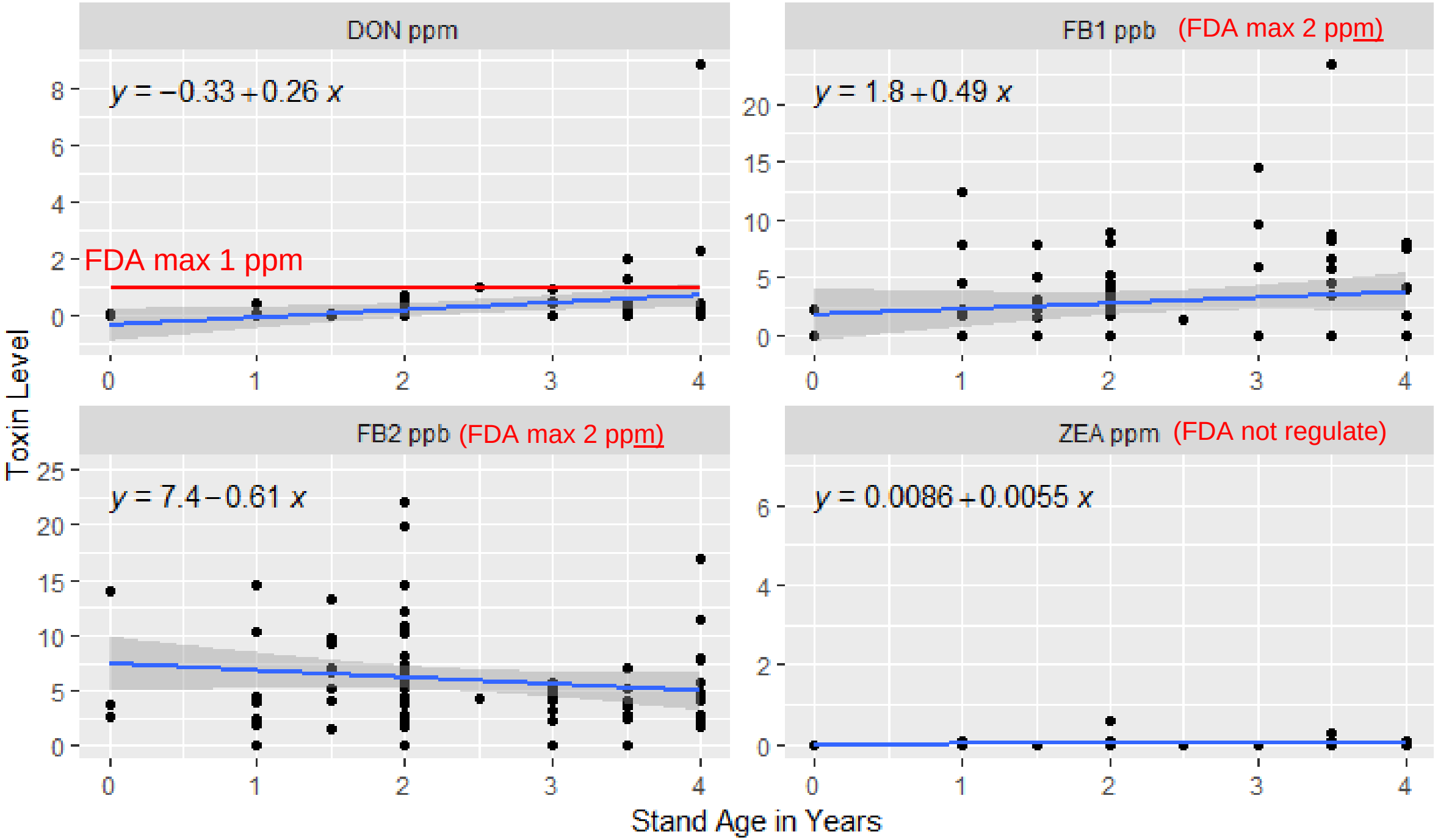
- Yield related to Fhb and slightly to Glume blotch (bacterial)
- Still do not observe yield penalties due to leaf diseases

SARE Grower questions – increase time?





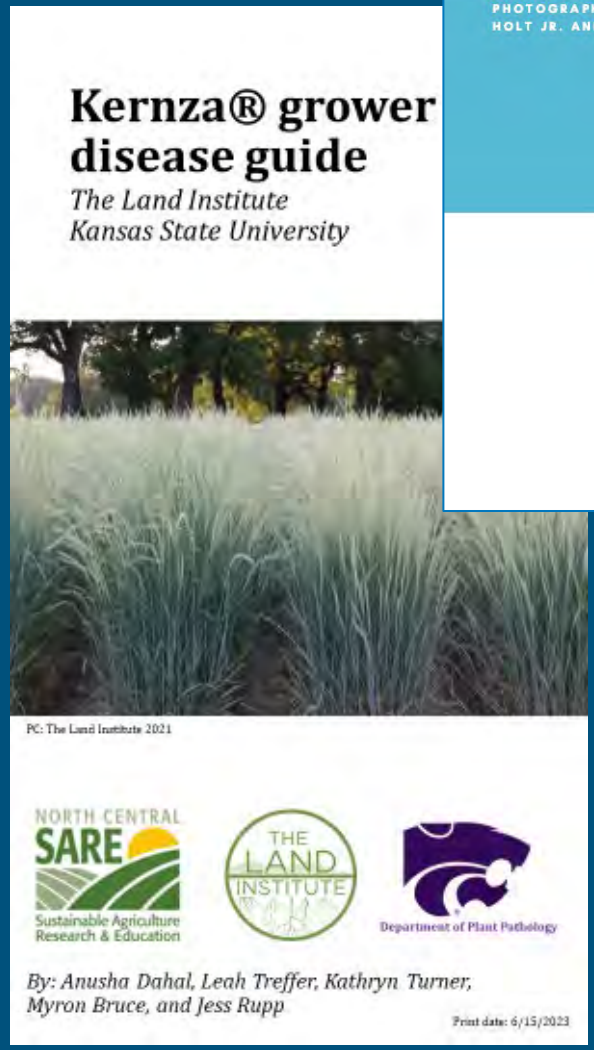
- Increase in disease but not toxin over time in our nurseries

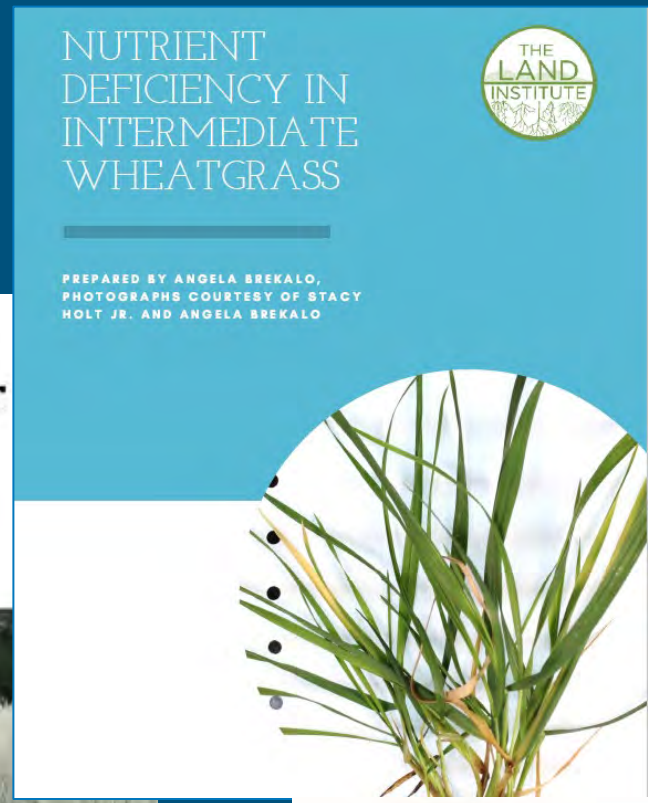

DON ppm
y = −0.33 + 0.26 x
FDA max 1 ppm
FB1 ppb (FDA max 2 ppm)
y = 1.8 + 0.49 x
FB2 ppb (FDA max 2 ppm)
y = 7.4 − 0.61 x
ZEA ppm (FDA not regulate)
y = 0.0086 + 0.0055 x
Toxin Level
Stand Age in Years

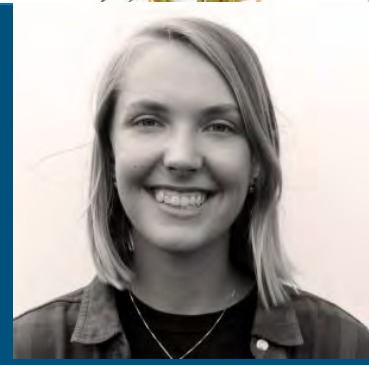
2022 Data set

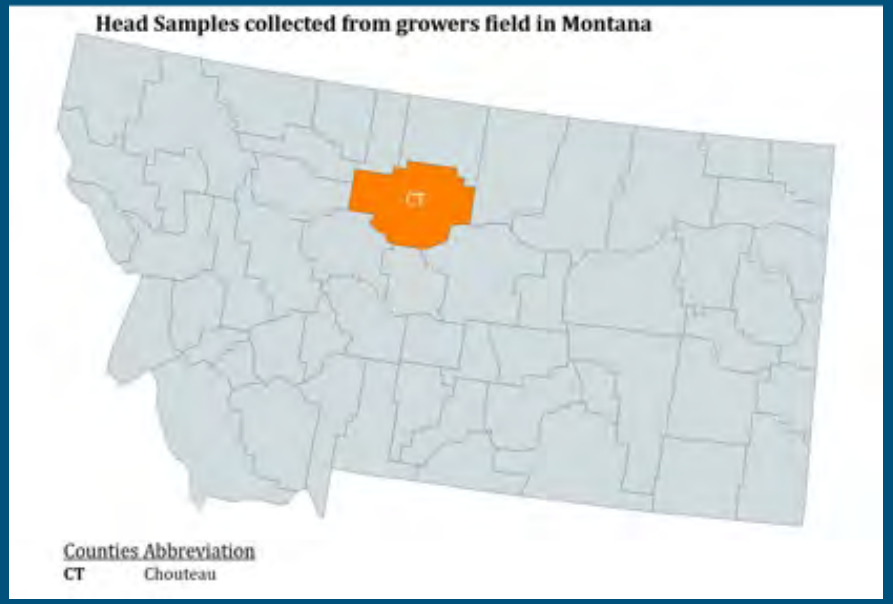
Building tools

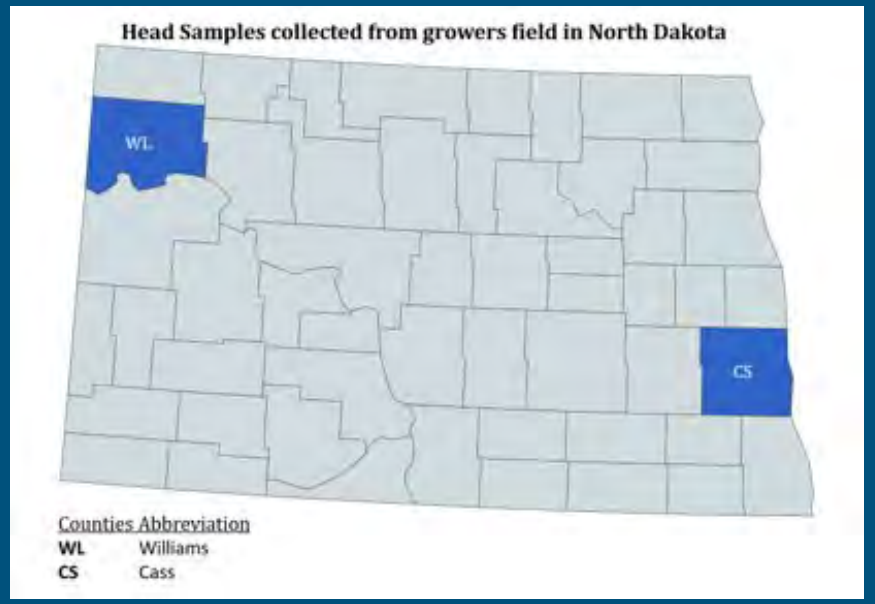
GWAS loci involved in disease resistance	
Trait (IWG gene)	Blast description
DON/ZON	Involved in pathogen
Loci in Fhb1 region	
Trait	NCBI Blast description
FHBDON S03	Sumai 3 Fhb 1 region – Zinc finger





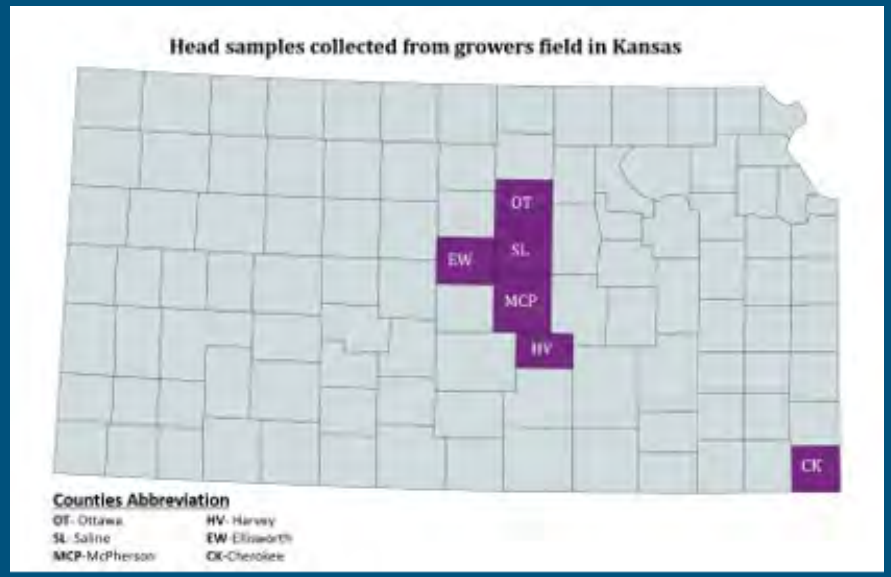






Request your help

- Sampling grain for toxins
- Building research networks and extension



Organic Agriculture Research and Extension Initiative (USDA-OREI)

United States Department of Agriculture
National Institute of Food and Agriculture

Organic Dual-Use Perennial Grain Crops: Pathways to Profitability and Soil Health

Leonardo Deiss

June 22nd, 2023

THE OHIO STATE UNIVERSITY

THE LAND INSTITUTE

UNIVERSITY OF MINNESOTA

Cornell University

Project Objectives

The goal is to help alleviate key production, economic, and market constraints of promising perennial grain crops, when managed to **produce both grain and forage**.

Specific objectives:

- Agronomic trials (Objectives 1 and 2)
- Enterprise budgets for organic systems (Obj. 3)
- Farmer networks and commercialization efforts (Obj. 4)

Agronomic trials

A) **Establish management recommendations to optimize organic dual-use grain and forage production of perennial crops**

B) **Quantify improvements that perennial crops have on soil health**

Agronomic trials:

- **Kernza Dual-Use (KODU)**
- **Kernza-Legume Intercrop (KLI)**
- Organic Perennial Wheat (OPW)

Sites: Ohio (2 sites), New York, Minnesota, and Kansas

Measures:

- Soil health assessment (bio, chem, phys indicators)
- Crop yield (grain and forage), below- and above-ground biomass, and perenniality (grid)

Kernza after defoliation. Wooster, Oct 27th, 2022

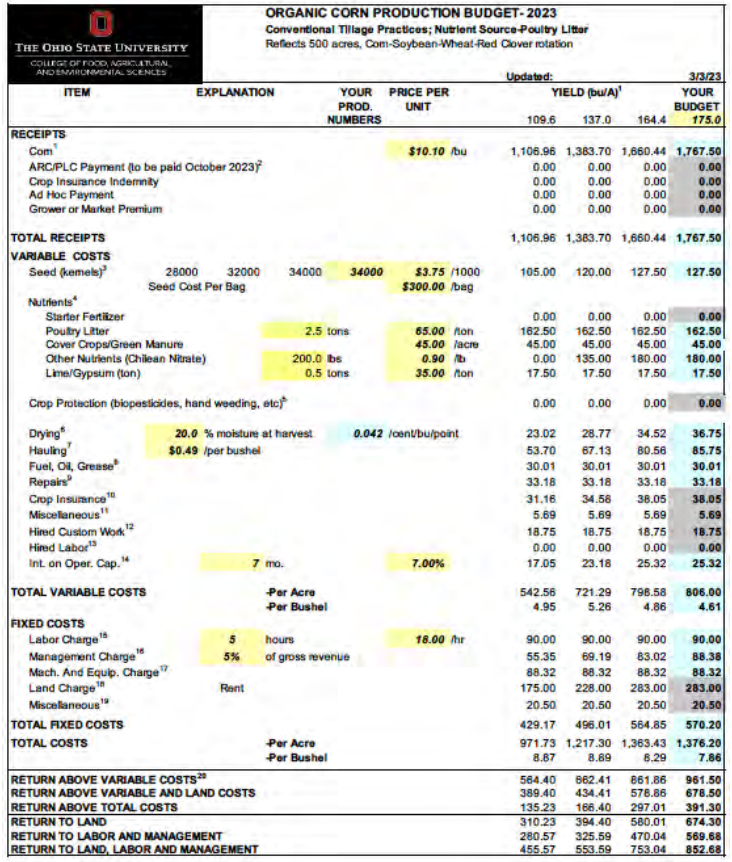
Kernza + Clover vs. sole cropping. Wooster, May 26th, 2023

Enterprise budgets

Objective 3. **Develop enterprise budgets to identify economic indicators that could increase or limit adoption of perennial grain systems**

Enterprise budgets with focus on **organic** perennial grain systems (fixed and variable costs, financial return)

- Dual-Use: Grain and Forage production
- Management:
  - Manure
  - Legume Intercropping



THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

ORGANIC CORN PRODUCTION BUDGET- 2023
Conventional Tillage Practices; Nutrient Source-Poultry Litter
Reflects 500 acres, Corn-Soybean-Wheat-Red Clover rotation

Updated: 3/3/23

ITEM	EXPLANATION	YOUR PROD. NUMBERS	PRICE PER UNIT	YIELD (bu/A)[1] 109.6	137.0	164.4	YOUR BUDGET 175.0
RECEIPTS							
Corn[1]			$10.10 /bu	1,106.96	1,383.70	1,660.44	1,767.50
ARC/PLC Payment (to be paid October 2023)[2]				0.00	0.00	0.00	0.00
Crop Insurance Indemnity				0.00	0.00	0.00	0.00
Ad Hoc Payment				0.00	0.00	0.00	0.00
Grower or Market Premium				0.00	0.00	0.00	0.00
TOTAL RECEIPTS				1,106.96	1,383.70	1,660.44	1,767.50
VARIABLE COSTS							
Seed (kernels)[3]	28000 32000 34000	34000	$3.75 /1000	105.00	120.00	127.50	127.50
	Seed Cost Per Bag		$300.00 /bag				
Nutrients[4]							
Starter Fertilizer				0.00	0.00	0.00	0.00
Poultry Litter		2.5 tons	65.00 /ton	162.50	162.50	162.50	162.50
Cover Crops/Green Manure			45.00 /acre	45.00	45.00	45.00	45.00
Other Nutrients (Chilean Nitrate)		200.0 lbs	0.90 /lb	0.00	135.00	180.00	180.00
Lime/Gypsum (ton)		0.5 tons	35.00 /ton	17.50	17.50	17.50	17.50
Crop Protection (biopesticides, hand weeding, etc)[5]				0.00	0.00	0.00	0.00
Drying[6]	20.0 % moisture at harvest		0.042 /cent/bu/point	23.02	28.77	34.52	36.75
Hauling[7]	$0.49 /per bushel			53.70	67.13	80.56	85.75
Fuel, Oil, Grease[8]				30.01	30.01	30.01	30.01
Repairs[9]				33.18	33.18	33.18	33.18
Crop Insurance[10]				31.16	34.58	36.05	36.05
Miscellaneous[11]				5.69	5.69	5.69	5.69
Hired Custom Work[12]				18.75	18.75	18.75	18.75
Hired Labor[13]				0.00	0.00	0.00	0.00
Int. on Oper. Cap.[14]	7 mo.		7.00%	17.05	23.18	25.32	25.32
TOTAL VARIABLE COSTS		-Per Acre		542.56	721.29	798.58	806.00
		-Per Bushel		4.95	5.26	4.86	4.61
FIXED COSTS							
Labor Charge[15]	5 hours		18.00 /hr	90.00	90.00	90.00	90.00
Management Charge[16]	5% of gross revenue			55.35	69.19	83.02	88.38
Mach. And Equip. Charge[17]				88.32	88.32	88.32	88.32
Land Charge[18]	Rent			175.00	228.00	283.00	283.00
Miscellaneous[19]				20.50	20.50	20.50	20.50
TOTAL FIXED COSTS				429.17	496.01	564.85	570.20
TOTAL COSTS		-Per Acre		971.73	1,217.30	1,363.43	1,376.20
		-Per Bushel		8.87	8.89	8.29	7.86
RETURN ABOVE VARIABLE COSTS[20]				564.40	662.41	861.86	961.50
RETURN ABOVE VARIABLE AND LAND COSTS				389.40	434.41	578.86	678.50
RETURN ABOVE TOTAL COSTS				135.23	166.40	297.01	391.30
RETURN TO LAND				310.23	394.40	580.01	674.30
RETURN TO LABOR AND MANAGEMENT				280.57	325.59	470.04	569.68
RETURN TO LAND, LABOR AND MANAGEMENT				455.57	553.59	753.04	852.68

Farmer networks and commercialization efforts

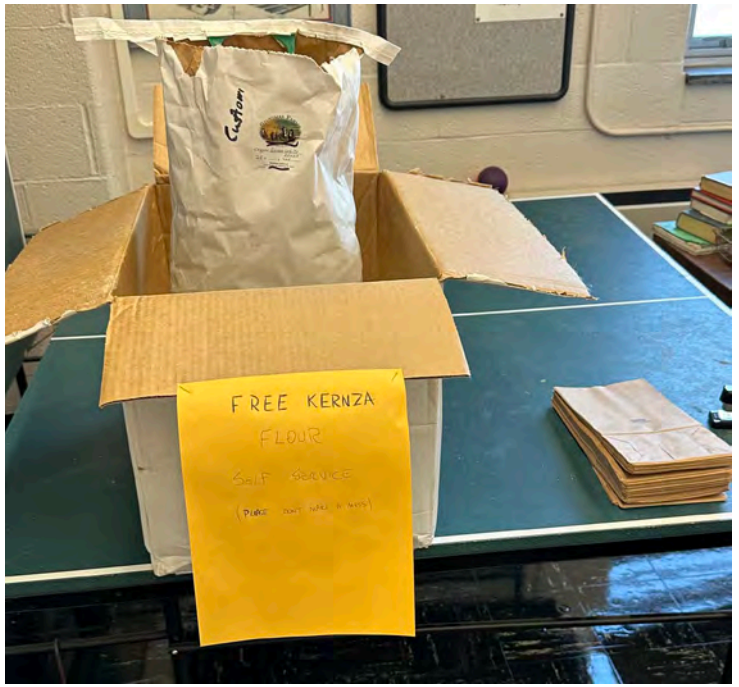
Objective 4. **Integrate research activities and farmer networks into existing perennial crop commercialization efforts**

Donation of 800 lbs. of harvested organic grains to:

- **a baker** (Avalanche Pizza, Athens - OH)
- **an organic grain mill** (Stutzman Farms and Mill, Millersburg - OH)

John Gutekanst, 2023 - Avalanche Pizza, Athens, OH

Free Kernza four self-service at OSU campus



OSU - Wooster, OH, 2023

The impact of nitrogen rates across sites and years on intermediate wheatgrass grain yields: A meta-analysis

Roberta Bianchin Rebesquini
MS Student – University of Nebraska – Lincoln
Adviser – Dr. Andrea Basche
Resilient Cropping Systems Lab

TITLE, ABSTRACT & KEY WORDS

"kernza" OR "intermediate wheatgrass" OR "thinopyrum intermedium"

+

"nitrogen" OR "nitrogen rate" OR "nitrogen application"

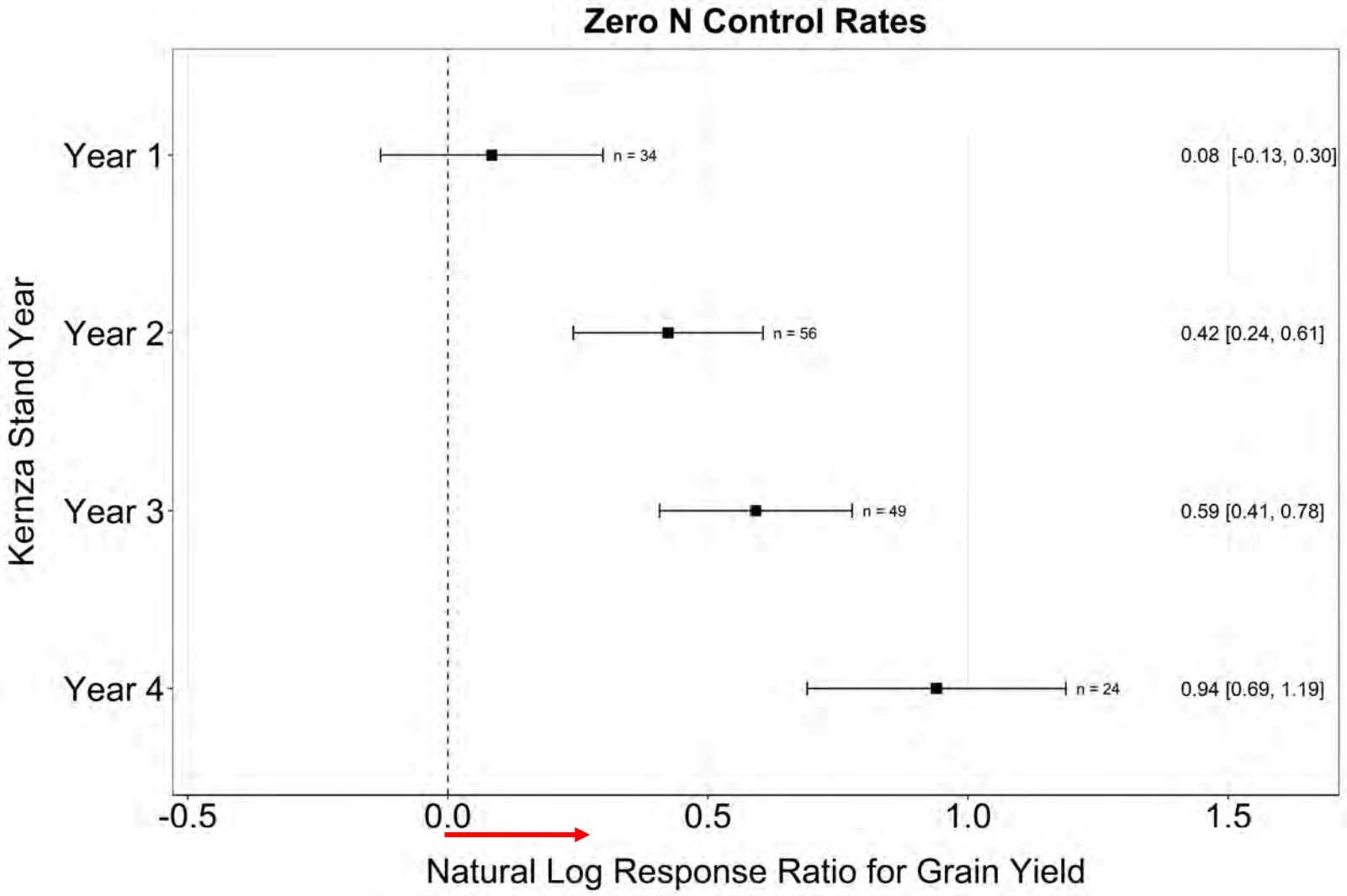
Screening criteria:

1. Field studies evaluating at least 2 nitrogen rates
2. Studies evaluating Intermediate wheatgrass grain and/or biomass yield

16 Published articles + 1 unpublished multi-site trial

→ **263** comparisons by site-experiment year

→ Preliminary Results:



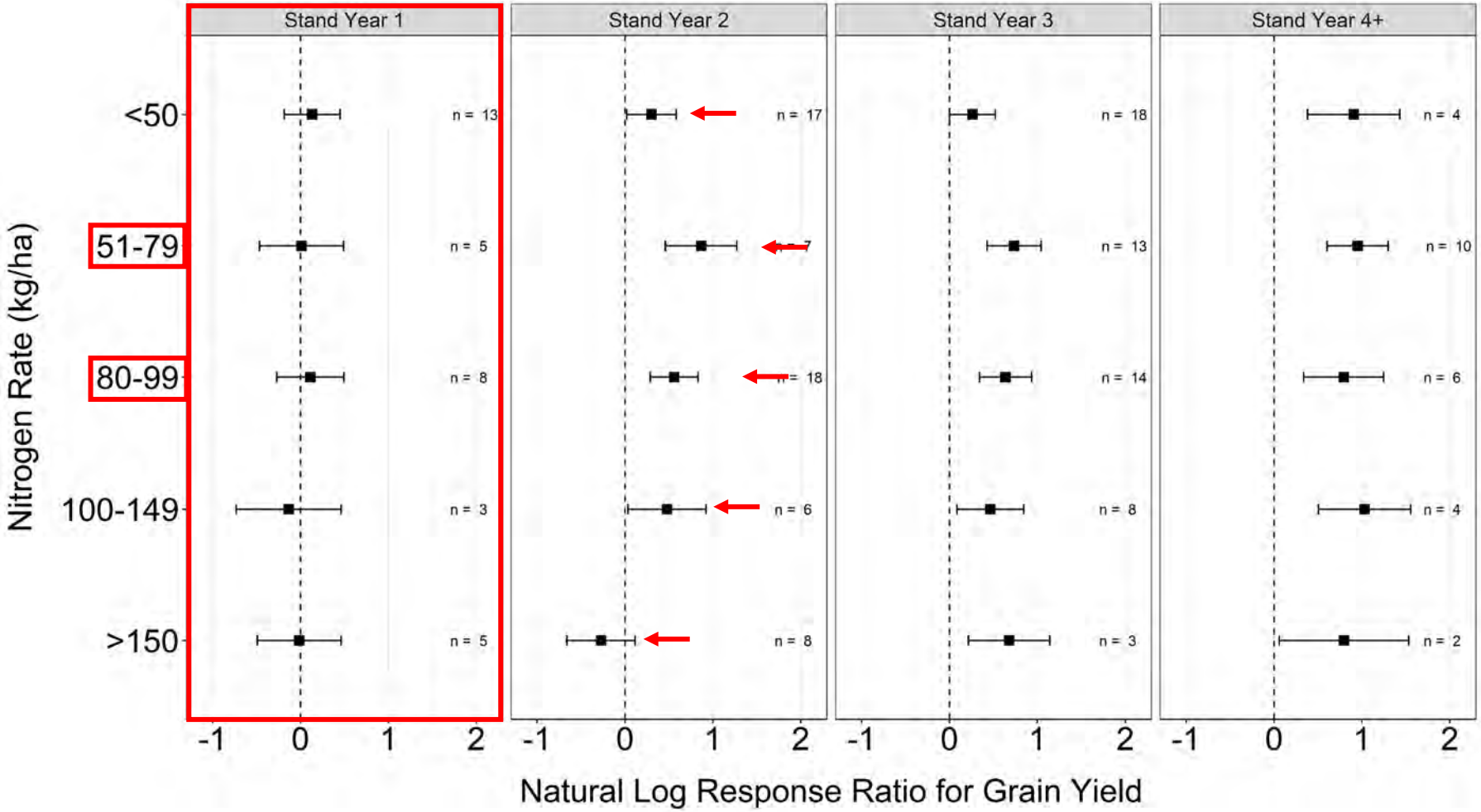
Response ratio above zero = Kernza response to N

- Response ratios represent a higher N rate divided by **control N rates (0)** where comparisons by site-experiment year were available.

- Estimated effect sizes and its respective 95% CI for grain yield, with response ratios separated by year of intermediate wheatgrass stand.

→ Preliminary Results:

Yield response ratio x Nitrogen Rate grouped by Kernza Stand Year



- Response ratios represent a higher N rate divided by **control N rates (0)** where comparisons by site-experiment year were available.
- Nitrogen rates separated by groups.
- **Limited effect** of N across rates in **year 1**, with greater N needs in later years.

Thank you!

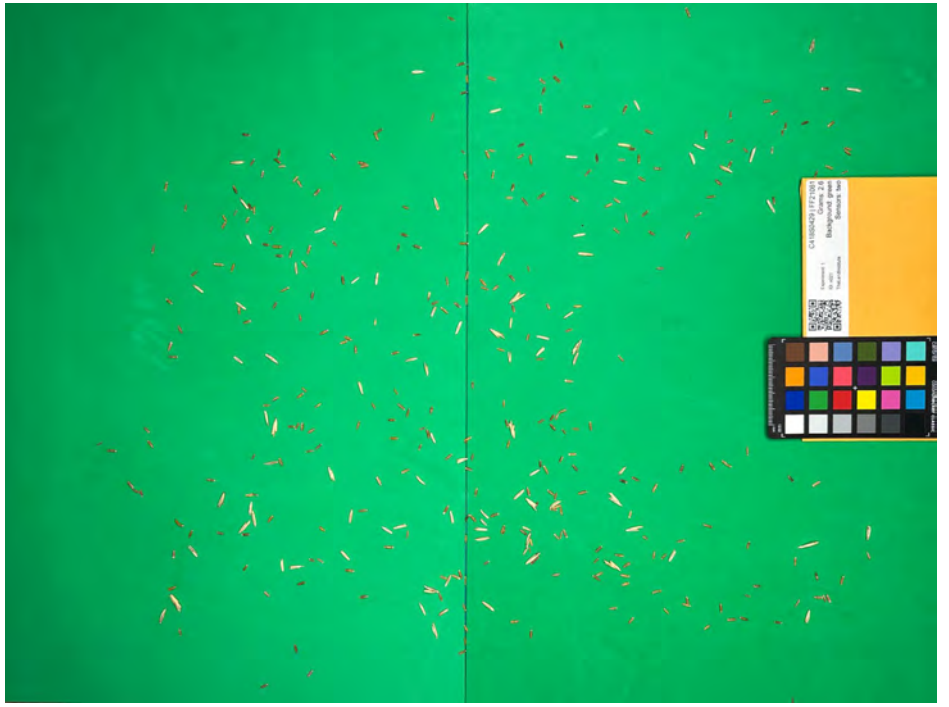
Automated Seed Quantification for Kernza

Garett Heineck, Lou Saporito, Collins Wakholi, Devin Rippner, Lee DeHaan

Kernza Con 2023

Identifying and quantifying components of Kernza grain

Methods: Collecting a representative dataset

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Grams: 0.2
Background: blue
Sensors: one


C418S0094 | FF22055
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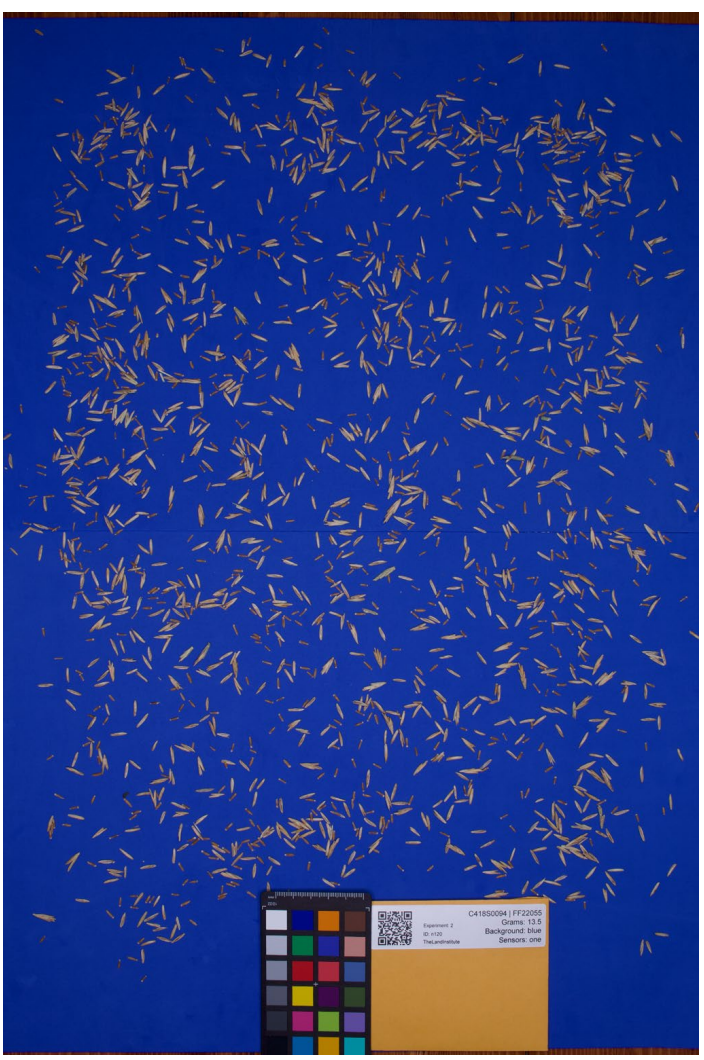
Sensors: one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Sensors: one


Rush | NuR01
Grams: 2.6
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Sensors: one


calibrite
colorchecker CLASSIC
Experiment: 1
ID: n005
TheLandInstitute
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Grams: 2.6
Background: white
Sensors: two

Camera Sensors	Image File Format	Imaging Platform (random)
Digital SLR/Point and Shoot 	Raw .Tiff 	Garett Heineck Prosser, WA 
Smartphone w/ RAW functionality 	.PNG 	Lou Saporito University Park, PA 
	.JPEG 	Lee DeHaan Salina, KS 
		Kernza Nerd 

Model development, training, implementation

roboflow

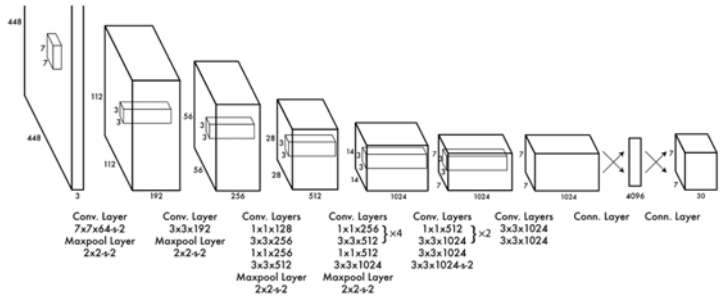
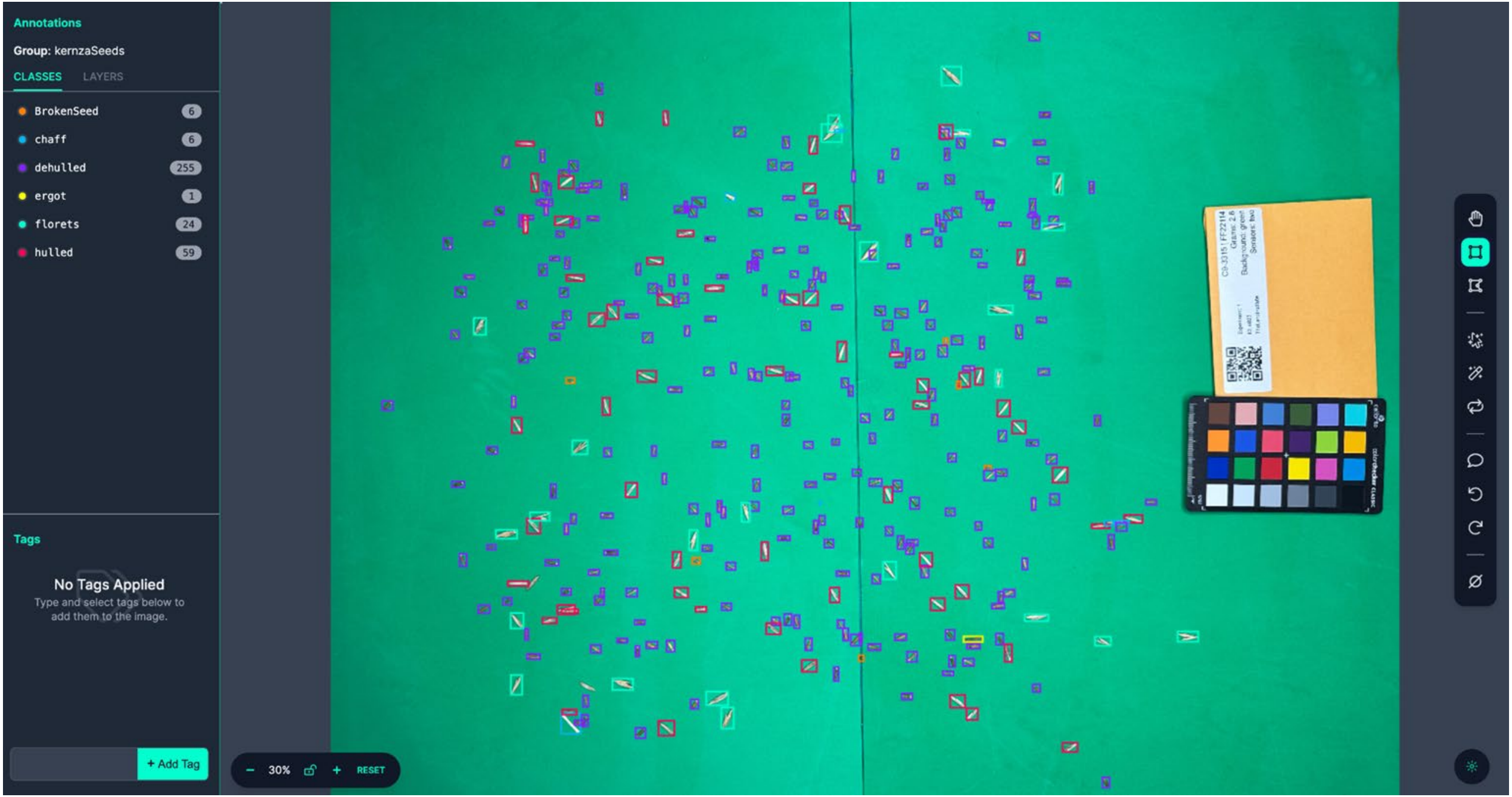


Figure 3: The Architecture. Our detection network has 24 convolutional layers followed by 2 fully connected layers. Alternating 1×1 convolutional layers reduce the features space from preceding layers. We pretrain the convolutional layers on the ImageNet classification task at half the resolution (224×224 input image) and then double the resolution for detection.

https://roboflow.com/; Redmon, J., Divvala, S., Girshick, R., & Farhadi, A. (2016). You only look once: Unified, real-time object detection. In Proceedings of the IEEE conference on computer vision and pattern recognition (pp. 779-788).; https://www.ilastik.org/

Segmentation vs. Object Detection


Annotations
Group: kernzaSeeds
CLASSES
LAYERS
BrokenSeed 6
chaff 6
dehulled 255
ergot 1
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hulled 59
Tags
No Tags Applied
Type and select tags below to add them to the image.
+ Add Tag
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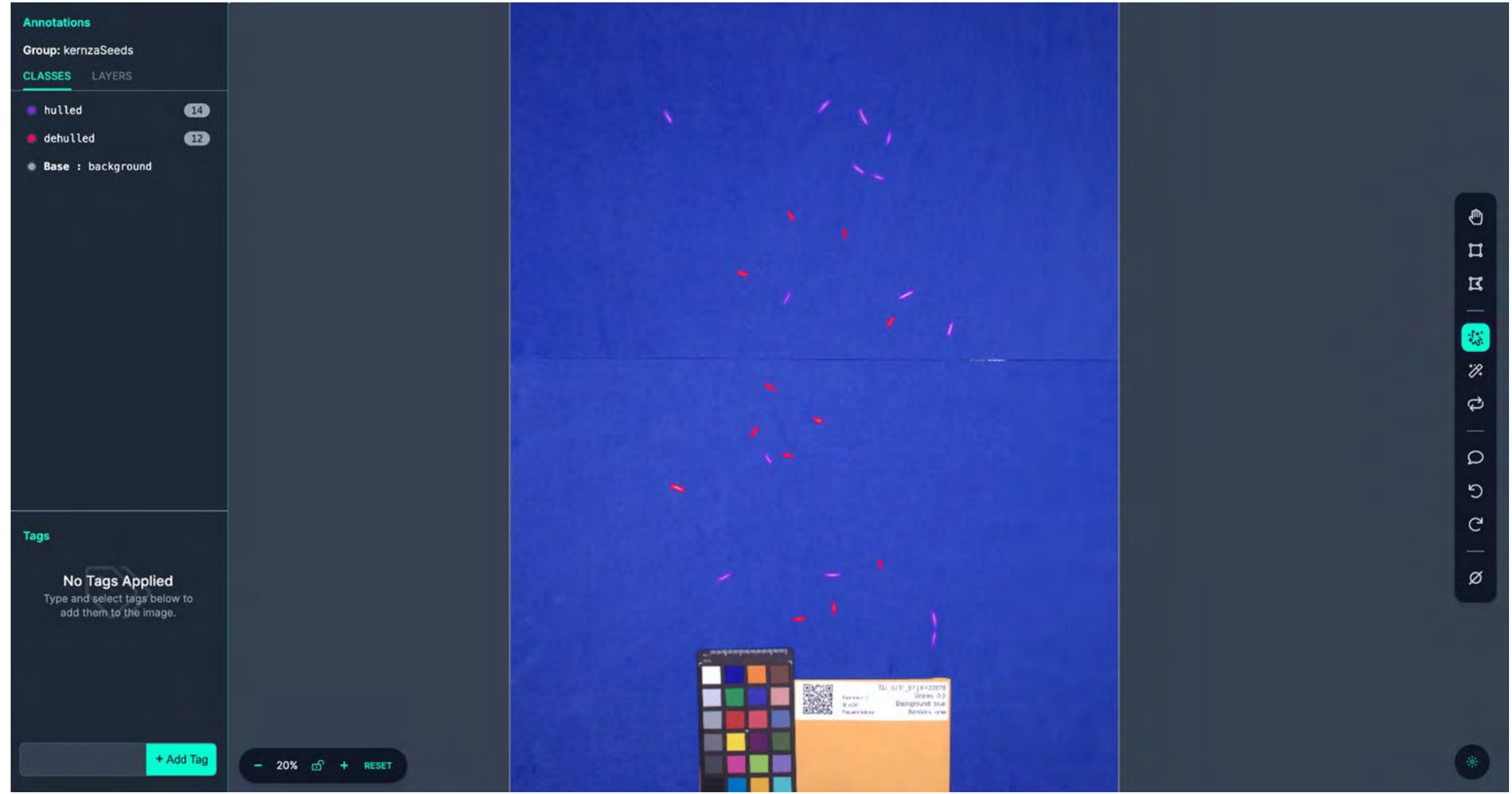
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CLASSES
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dehulled 12
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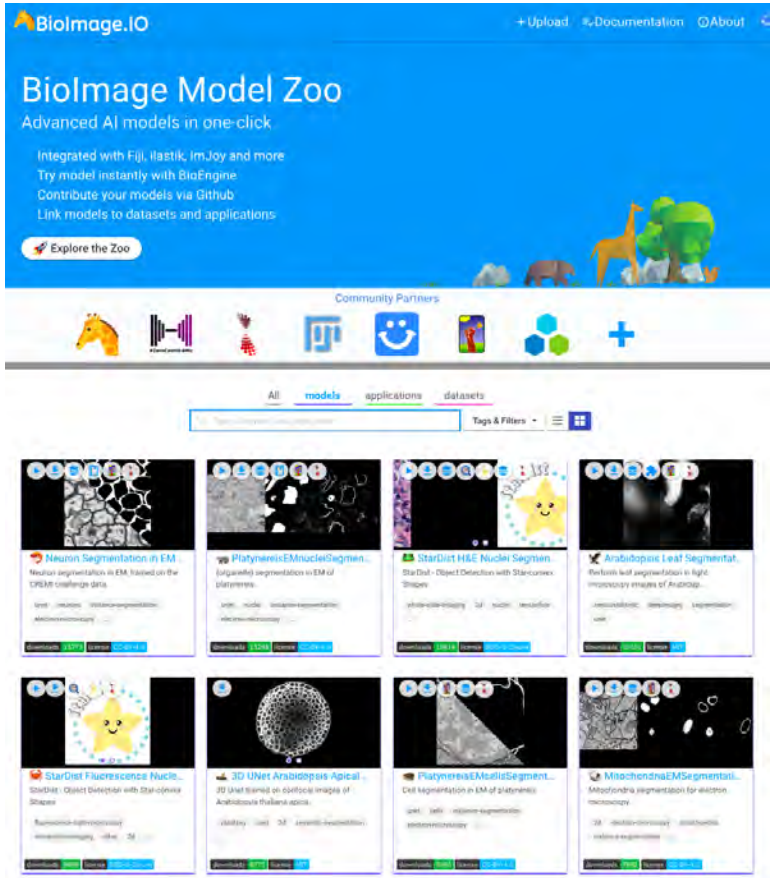
Impact: open source code on GitHub and Ilastik



https://github.com/logoshttps://bioimage.io/#/?partner=ilastik

USDA ARS: Kernza® Initiative

José G. Franco

U.S. Dairy Forage Research Center, Madison, WI

Presenting on behalf of the ARS Kernza® Initiative team

KernzaCon June 22-23, 2023

Photo credit: University of Minnesota

ARS Kernza® Initiative:

Regional and National Assessment

- Where does intermediate wheatgrass fit in today's systems?
  - *Diverse production systems across varying climates*
    - Semi-arid small grain production to temperate livestock forage & dual-use production
    - Rainfed to irrigated and dryland systems
- Can a dual-use, perennial crop improve the sustainability of agroecosystems?

USDA Agricultural Research Service

Pullman, WA

TRIAL & EVALUATION SITE

Dryland Systems

St. Paul, MN

BREEDING & LAB SITE

Forage and Soil Quality Lab

Crop and Grazing Systems

Madison, WI

DATA COORDINATION, TRIAL and EVALUATION SITE

Agronomic Data Coordination

Dairy Forage Production Systems

Crop and Conservation Systems

Kimberly, ID

TRIAL & EVALUATION SITE

Irrigated Systems

Univ. Park, PA

TRIAL & EVALUATION SITE

Crop, Grazing, and Conservation Systems

Logan, UT

GENETICS SITE

Semi-Arid Production Systems

RESEARCH PARTNERS

Colorado State University

THE LAND INSTITUTE

UNIVERSITY OF MINNESOTA

Fort Collins, CO

LAB, TRIAL, and DATA COORDINATION SITE

Brewing, Baking, and Grain Quality Lab

Dryland and Irrigated Systems

Livestock Utilization

Salina, KS

BREEDING SITE

Fayetteville, AR

TRIAL & EVALUATION SITE

Grazing and Conservation Systems

Map, with modifications, courtesy of Dr. Grace Miner, Soil Management and Sugarbeet Research Unit, Fort Collins, CO.

ARS Kernza® Initiative: Outcomes

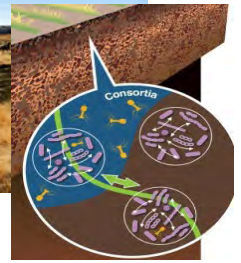
National Assessment

- Variety trial
  - Production (G × E)
    - Forage quality/nutritive value
    - Grain quality
  - Environmental
    - Soil health/soil quality
    - Air and water quality
  - End use
    - Brewing, baking quality

Flex crop

Drought tolerance
Efficient water use

Soil health
Carbon footprint

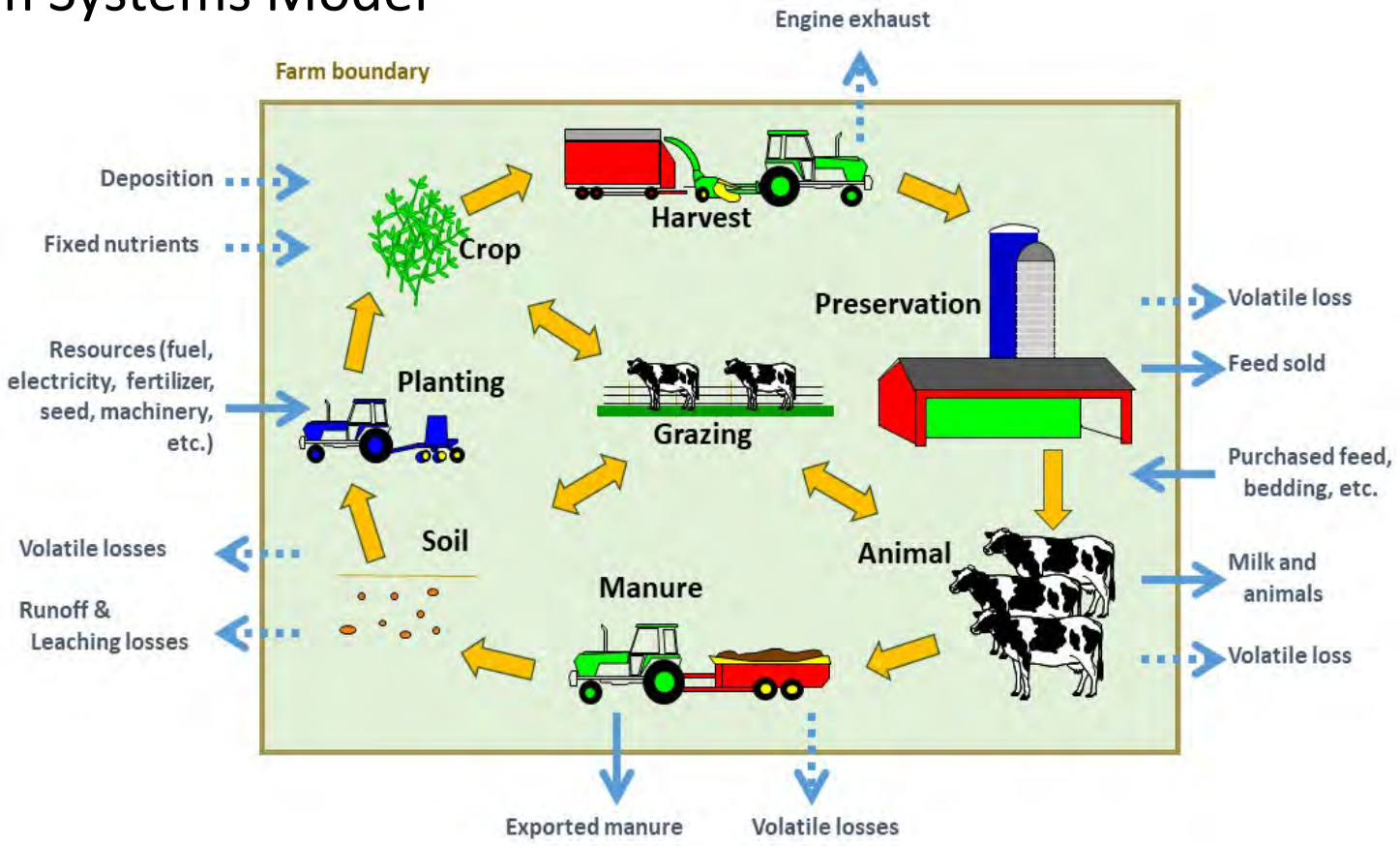


Graphics courtesy of Dr. Peter Kleinman, Soil Management and Sugarbeet Research Unit, Fort Collins, CO.

ARS Kernza® Initiative: Outcomes

Regional Assessment

- Farm systems: Integrated Farm Systems Model
  - Inputs
    - Grain yield
    - Forage yield
    - Fertilizer inputs
  - Outputs
    - Production costs
    - Nutrient losses
    - Carbon footprint
    - Water footprint
    - Fossil energy footprint



Graphic credit: Dr. Al Rotz, Pasture Systems & Watershed Management Research Unit, University Park, PA.

United States Department of Agriculture

Agricultural Research Service

Questions?

Contact Information

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Research Agroecologist

U.S. Dairy Forage Research Center

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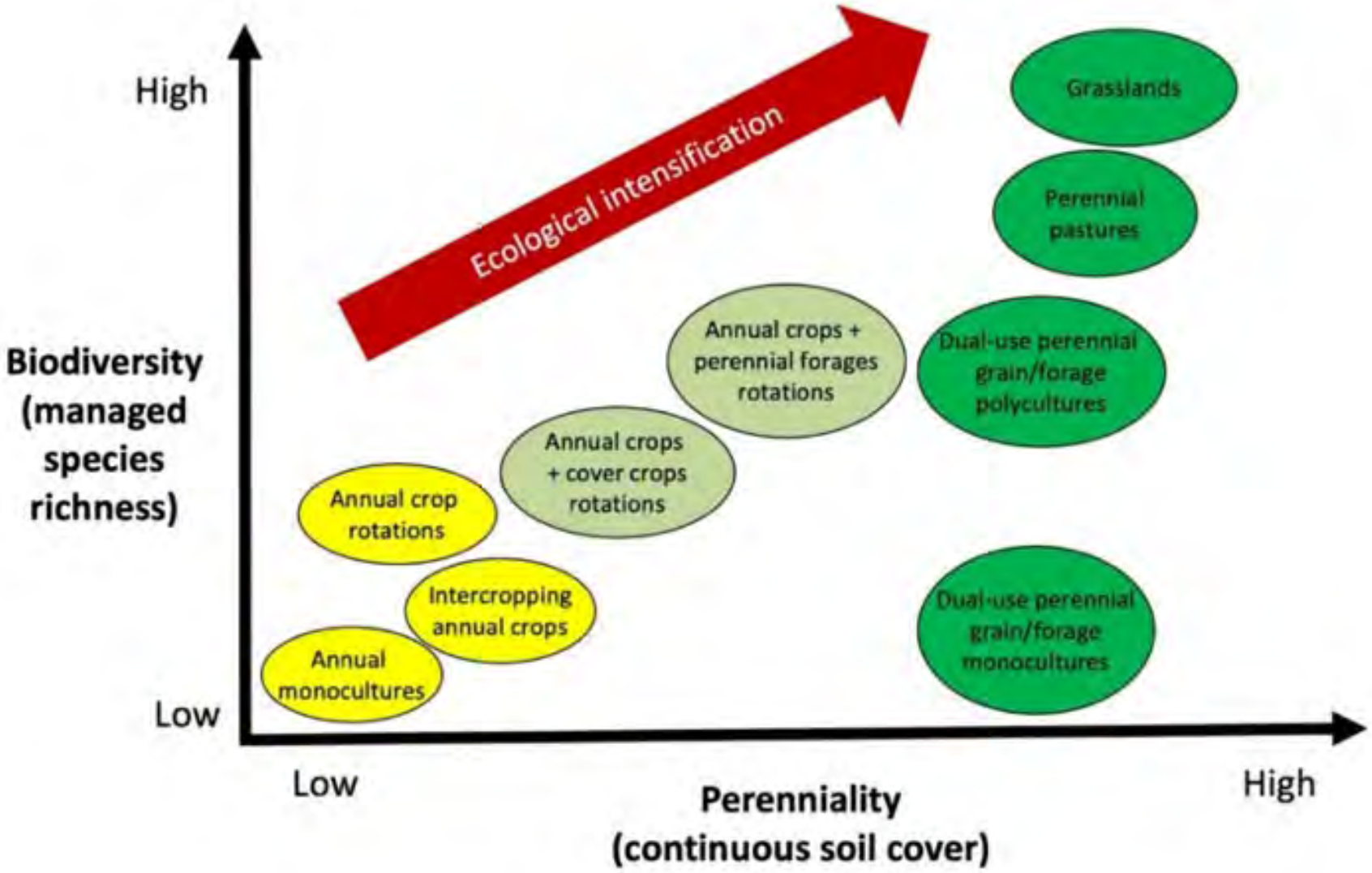
PCC Lab Logo credit: KC Cifizzari, U.S. Dairy Forage Research Center, Madison, WI.

IWG-Legume intercropping

Priscila Pinto

University of Wisconsin - Madison

Why intercrop?



Franco et al., 2021

IWG-Legume intercropping systems

IWG Control
45N, 90 N

Berseem clover

Kura clover

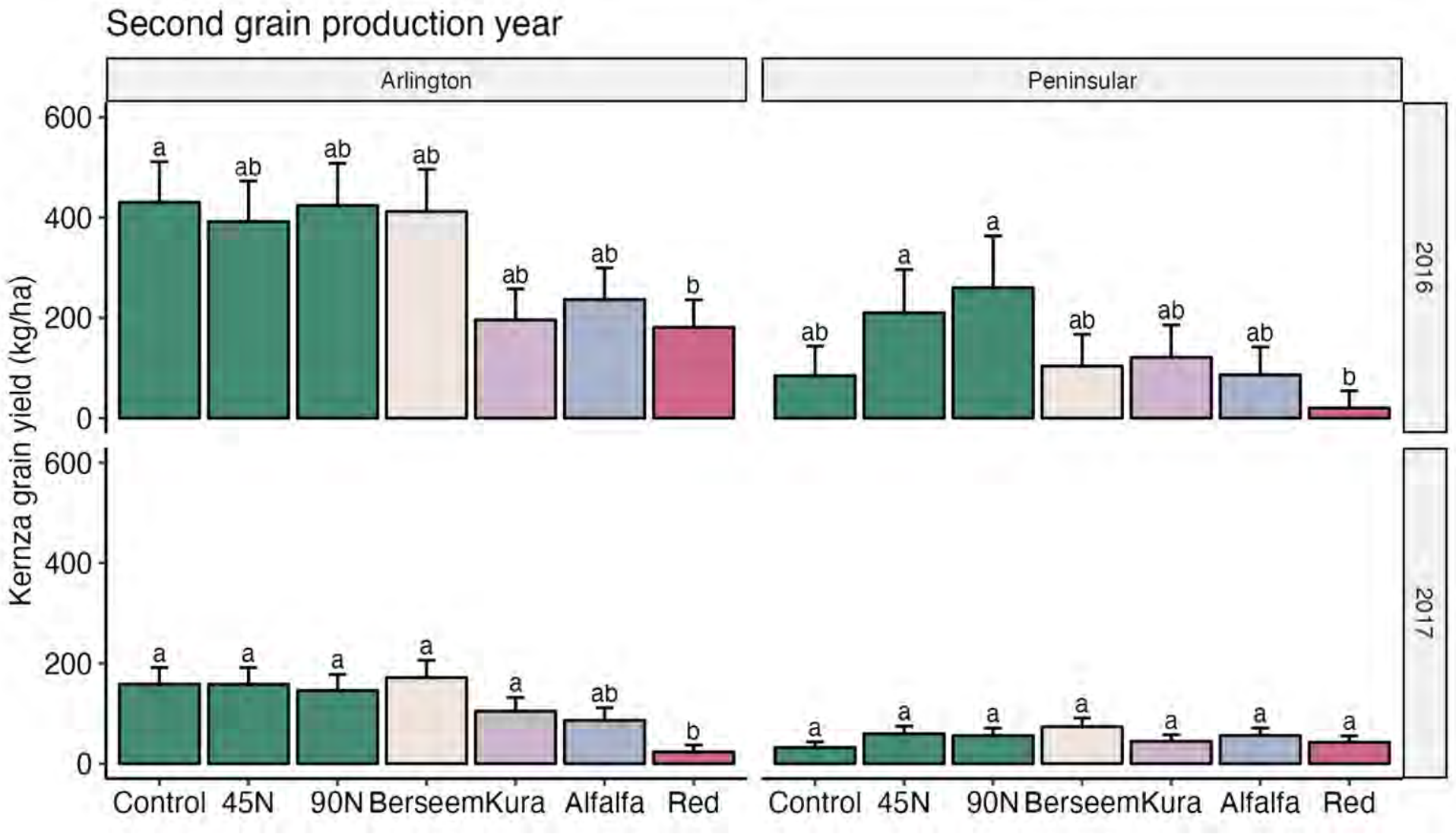
Alfalfa

Red clover

4 environments: Arlington16, Arlington17, Peninsular16, Peninsular17

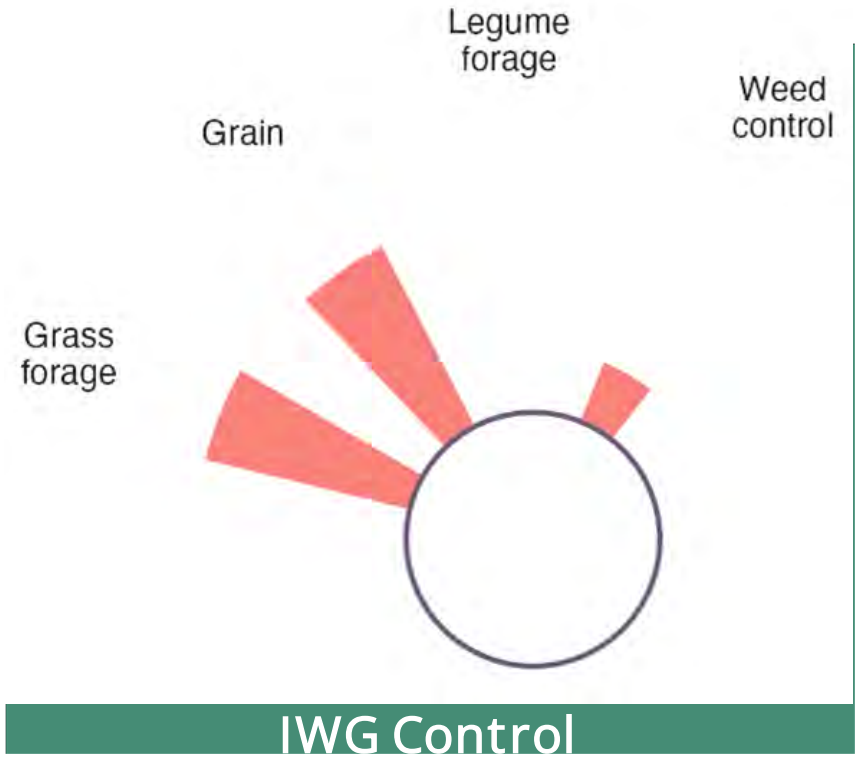
Kernza grain yield

First year: 610 kg/ha
Second year: 190 Kg/ha

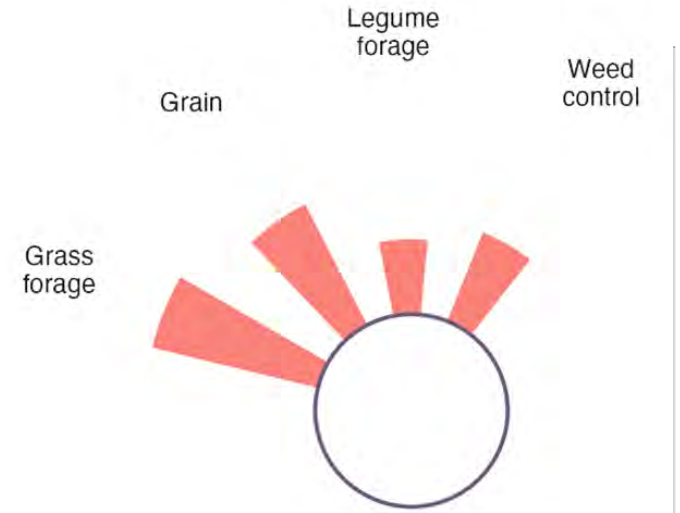


Pinto et al., in prep

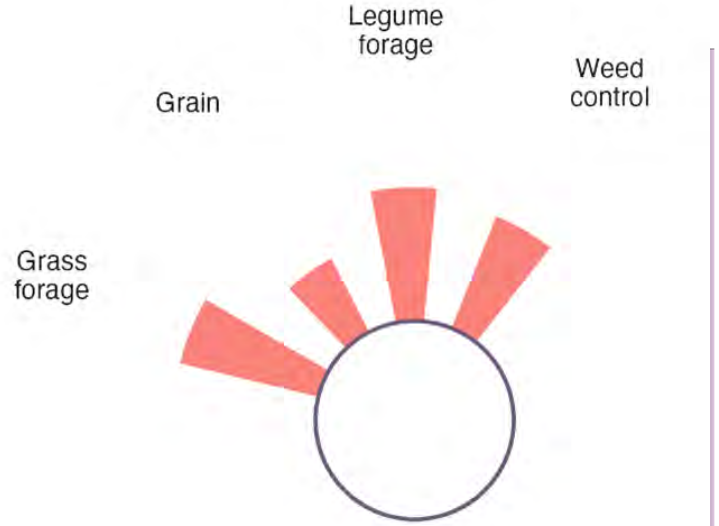
Dual-purpose systems



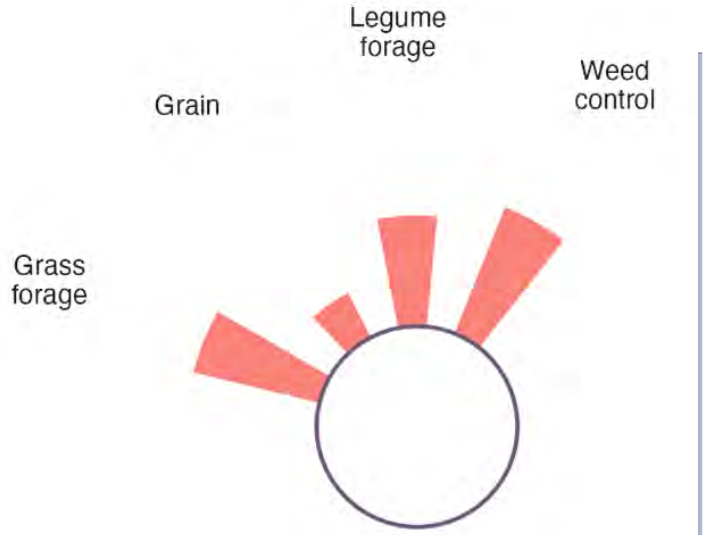
IWG Control



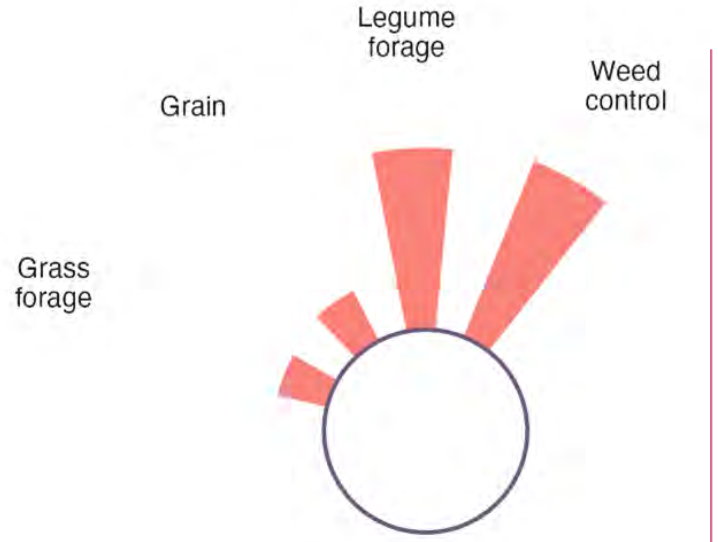
Berseem clover



Kura clover



Alfalfa



Red clover

Grazing Intermediate Wheatgrass (Kernza®) as a Dual-Use Crop for Forage and Grain Production

Impact of Grazing on Grain Yield
Profitability of Kernza

Photo Credit: Kaleb Anderson

CFANS

CLEAN RIVER PARTNERS

Kernza planting, Anderson Farm - Sep 10, 2018

Photo Credit: Clean River Partners


Direct Cut
Anderson Farm
Aug 23, 2019
Photo Credit: Clean River Partners


Kernza Grain Harvest
2019, Anderson Farm


Kernza Straw Bales, Anderson Farm
CFANS
CLEAN RIVER PARTNERS


Fall Grazing 2019,
Anderson Farm

Grazing Intermediate Wheatgrass (Kernza®) as a Dual-Use Crop for Forage and Grain Production - Timeline of Field Activities													
	Fall 2018	Spring 2019	Summer 2019	Fall 2019	Spring 2020	Summer 2020	Fall 2020	Spring 2021	Summer 2021	Fall 2021	Spring 2022	Summer 2022	Fall 2022
Anderson	Sprayed Glyphosate Sep 2	Sprayed 2,4-D Jul 3	Grain harvest Aug 23	Grazed Oct 15-20	Grazed May 15-22	Grain harvest Aug 8	Grazed Nov 1-10	Grazed May 10-16	Grain harvest - Aug 15	Grazed Oct 11 - Oct 17	Grazed May 19-25	Grazed Aug 25 - Sep 2	No Actvity - Very little biomass
	Planted no-till Sep 10	Rested, no grazing	Applied 5000 gal liq dairy manure		Applied 5000 gal liq dairy manure	Applied 5000 gal liq dairy manure		Applied 5000 gal liq dairy manure	Applied 5000 gal liq dairy manure		Applied 5000 gal liq dairy manure	Applied 5000 gal liq dairy manure	

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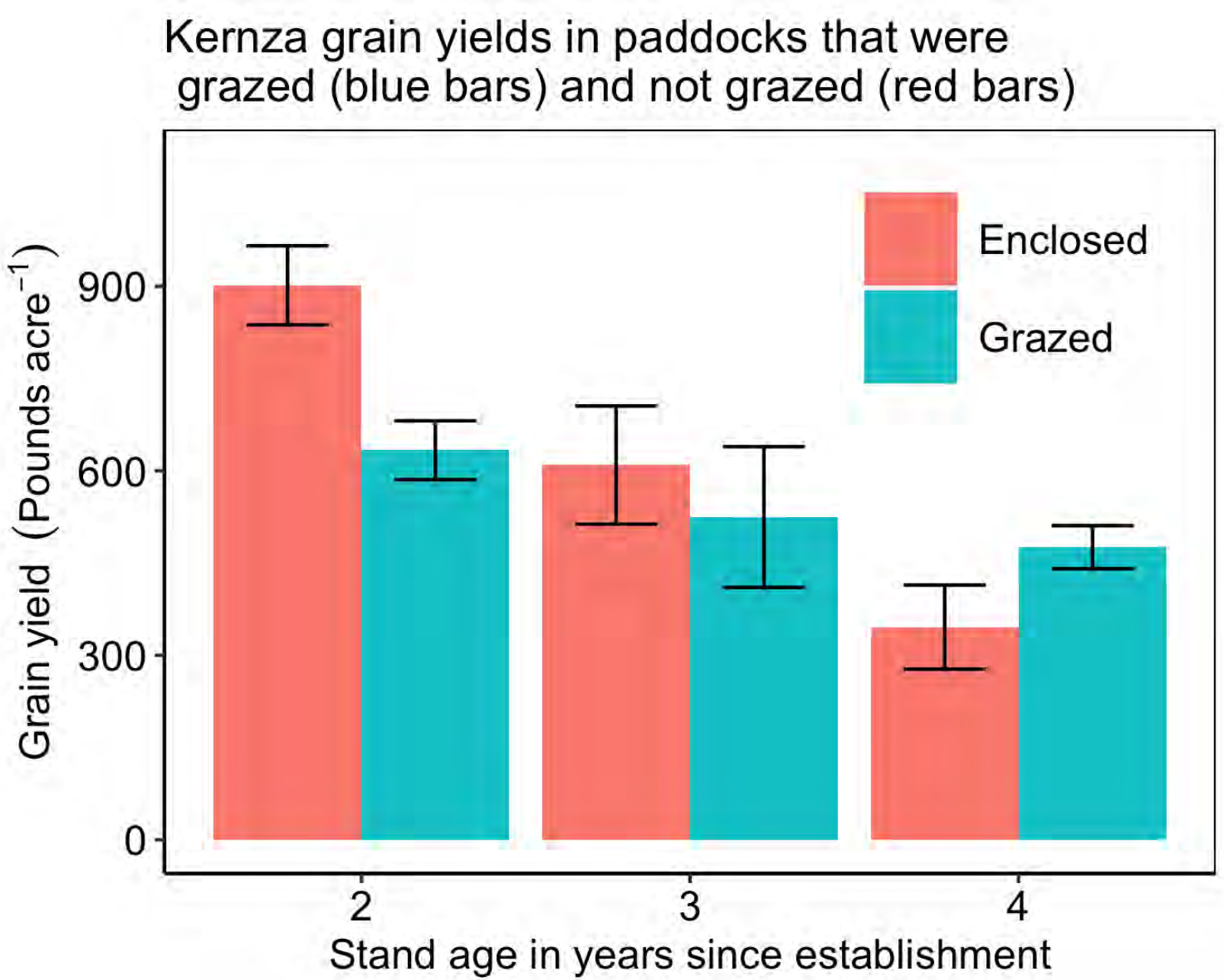
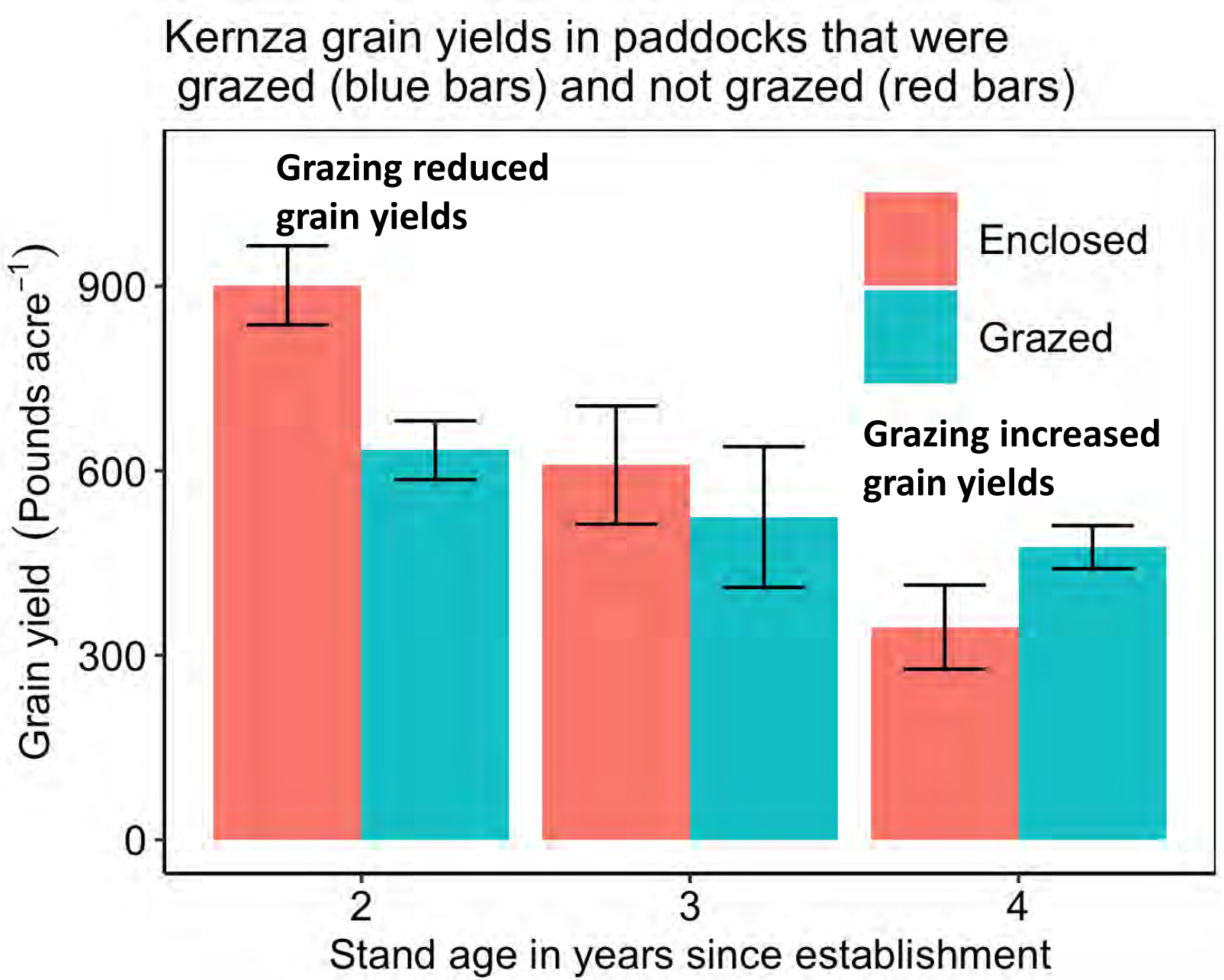
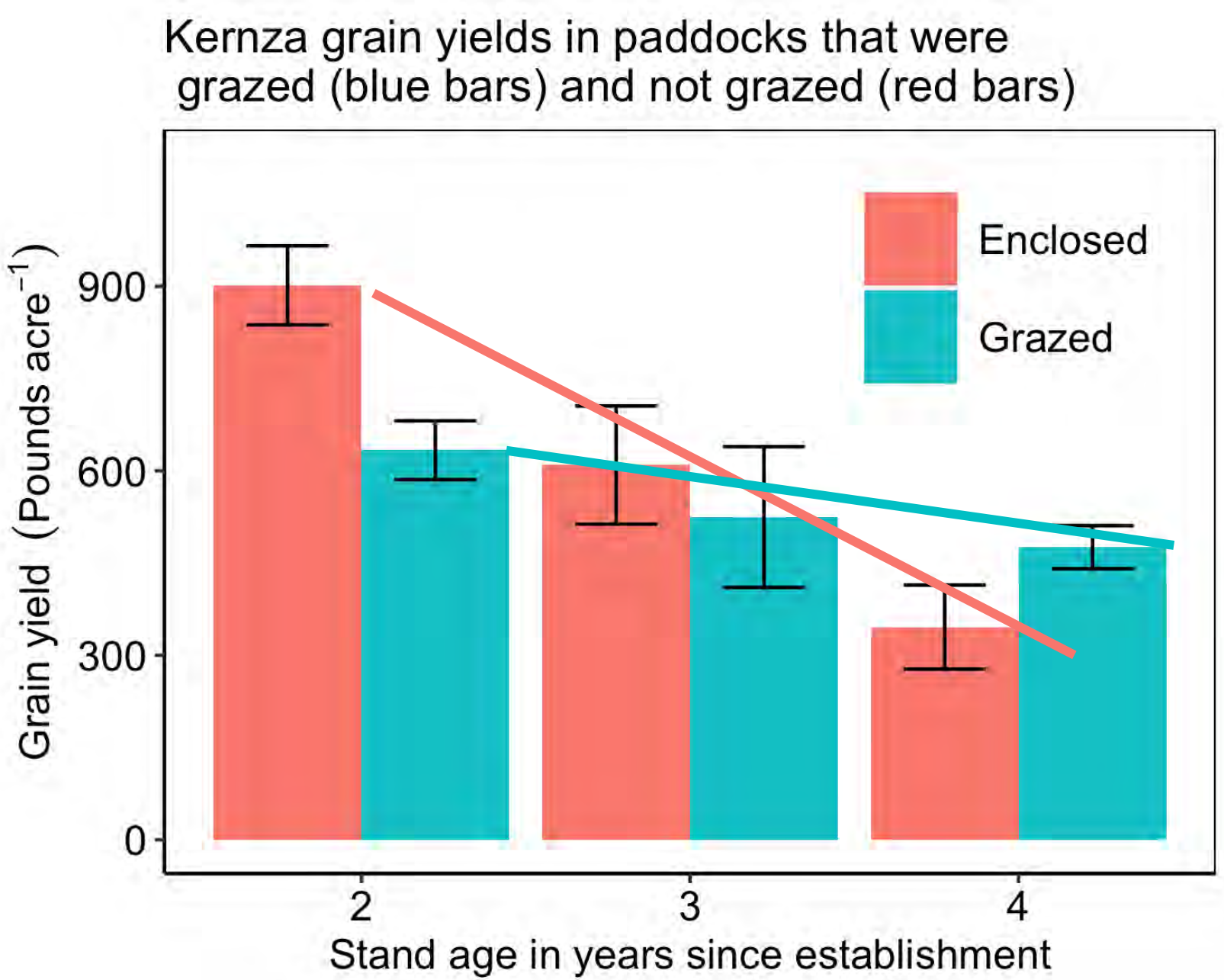
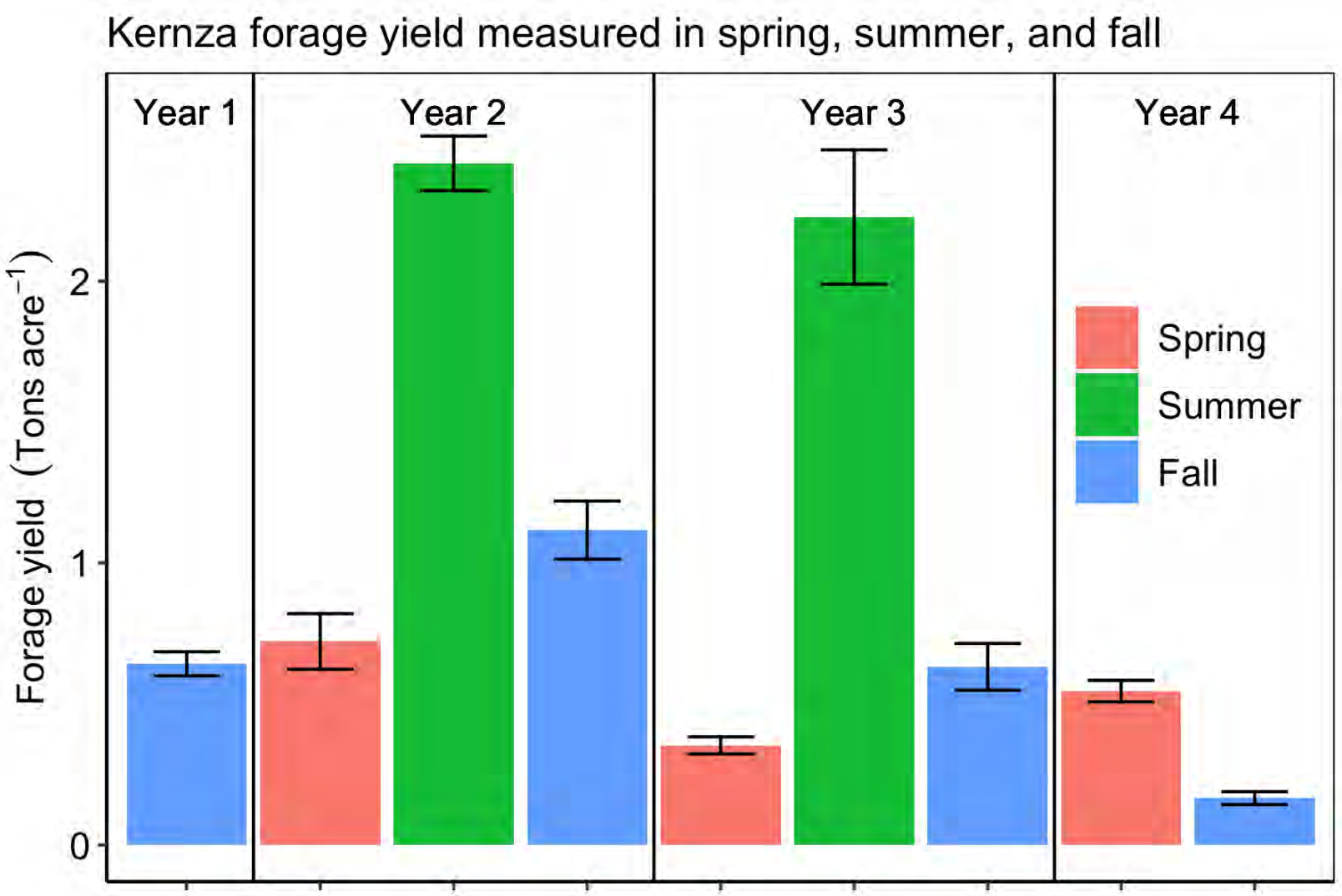
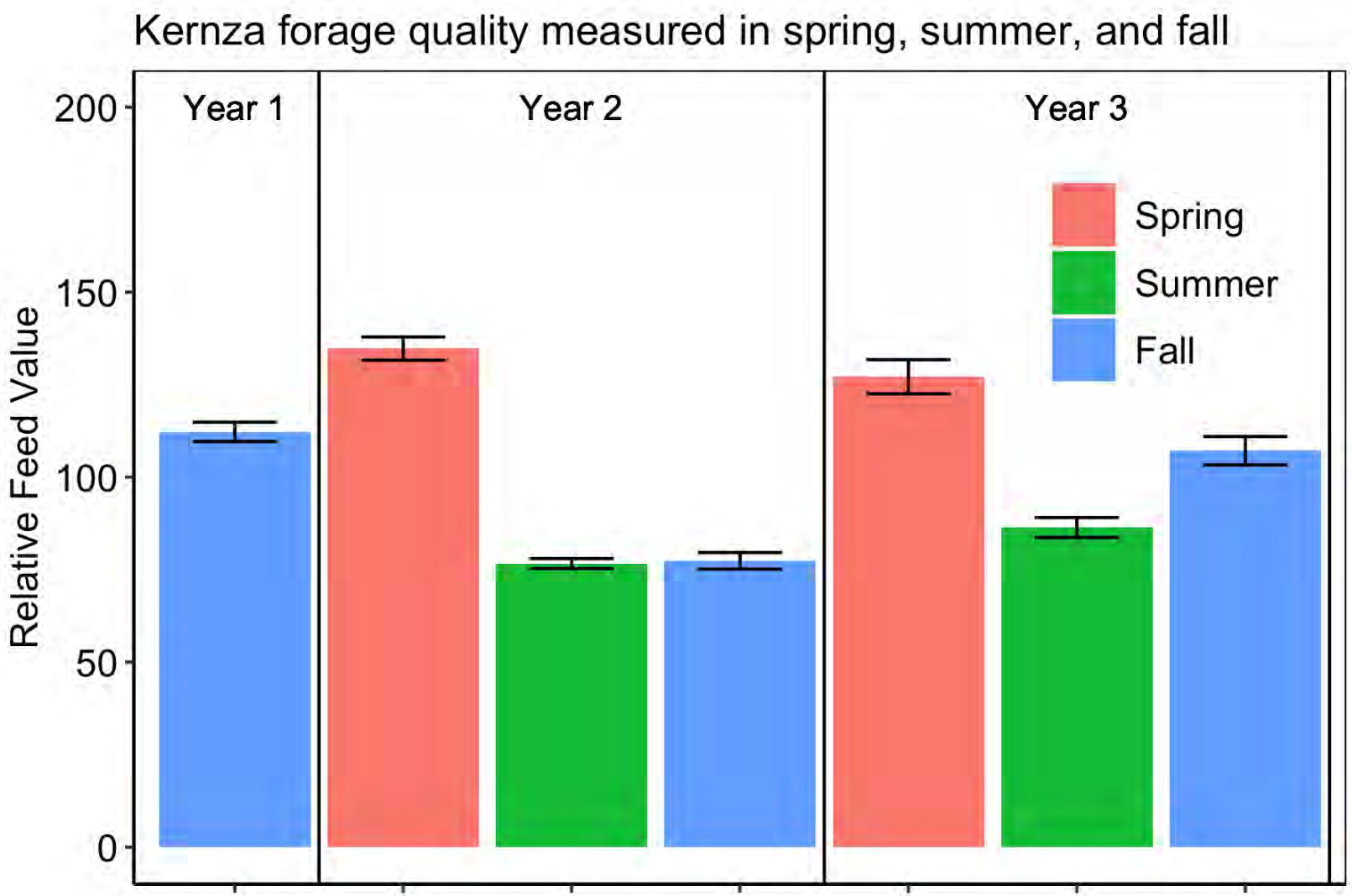

Kernza grain yields in paddocks that were grazed (blue bars) and not grazed (red bars)
Grain yield (Pounds acre^{-1})
900
600
300
0
Enclosed
Grazed
2
3
4
Stand age in years since establishment

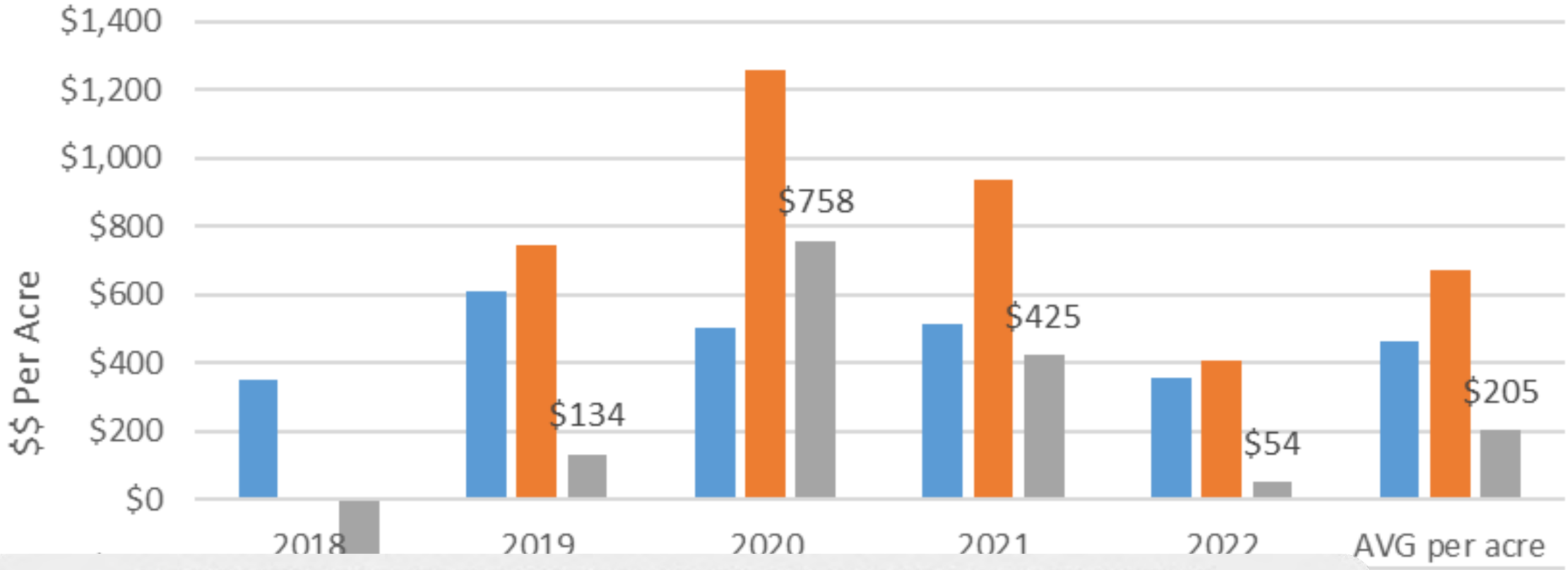

Kernza grain yields in paddocks that were grazed (blue bars) and not grazed (red bars)
Grazing reduced grain yields
Enclosed
Grazed
Grazing increased grain yields
Grain yield (Pounds acre^{-1})
900
600
300
0
2
3
4
Stand age in years since establishment

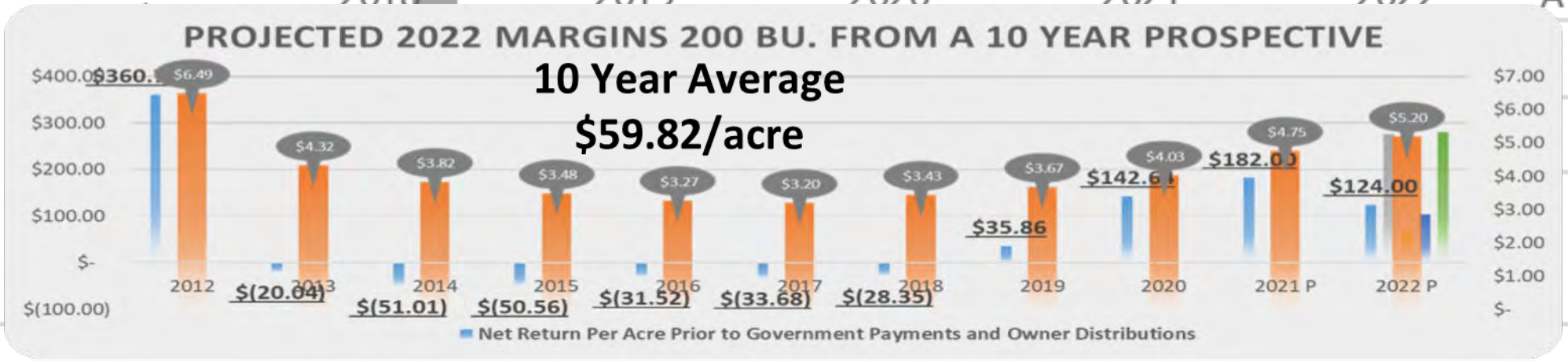

Kernza grain yields in paddocks that were grazed (blue bars) and not grazed (red bars)
Enclosed
Grazed
Grain yield (Pounds acre^{-1})
900
600
300
0
2
3
4
Stand age in years since establishment


Kernza forage yield measured in spring, summer, and fall
Year 1
Year 2
Year 3
Year 4
Forage yield (Tons acre^{-1})
0
1
2
Spring
Summer
Fall


Kernza forage quality measured in spring, summer, and fall
Year 1
Year 2
Year 3
Relative Feed Value
200
150
100
50
0
Spring
Summer
Fall

Economics of Dual Use Kernza





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Grazing Intermediate Wheatgrass (Kernza®) as a Dual-Use Crop for Forage and Grain Production

Impact of Grazing on Grain Yield
Profitability of Kernza

Photo Credit: Kaleb Anderson

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Food Science

Effect of Nitrogen Treatment on The Chemical Composition and Pasting Properties of Intermediate Wheatgrass

Obed Aduama, Food Science Graduate Student

Kernza®CAP

University of Minnesota
Driven to Discover℠

Rational

Nitrogen fertilization and its impact on IWG chemical composition and functional properties is not well understood.

This study evaluates the effect of nitrogen fertilization and when it is applied i.e. Spring or Fall on the chemical composition and pasting properties of IWG.

Analysis and Methodology

Sample preparation.

Whole grain samples: Milled IWG grain with Cyclone sample Mill equipped with 0.5mm screen

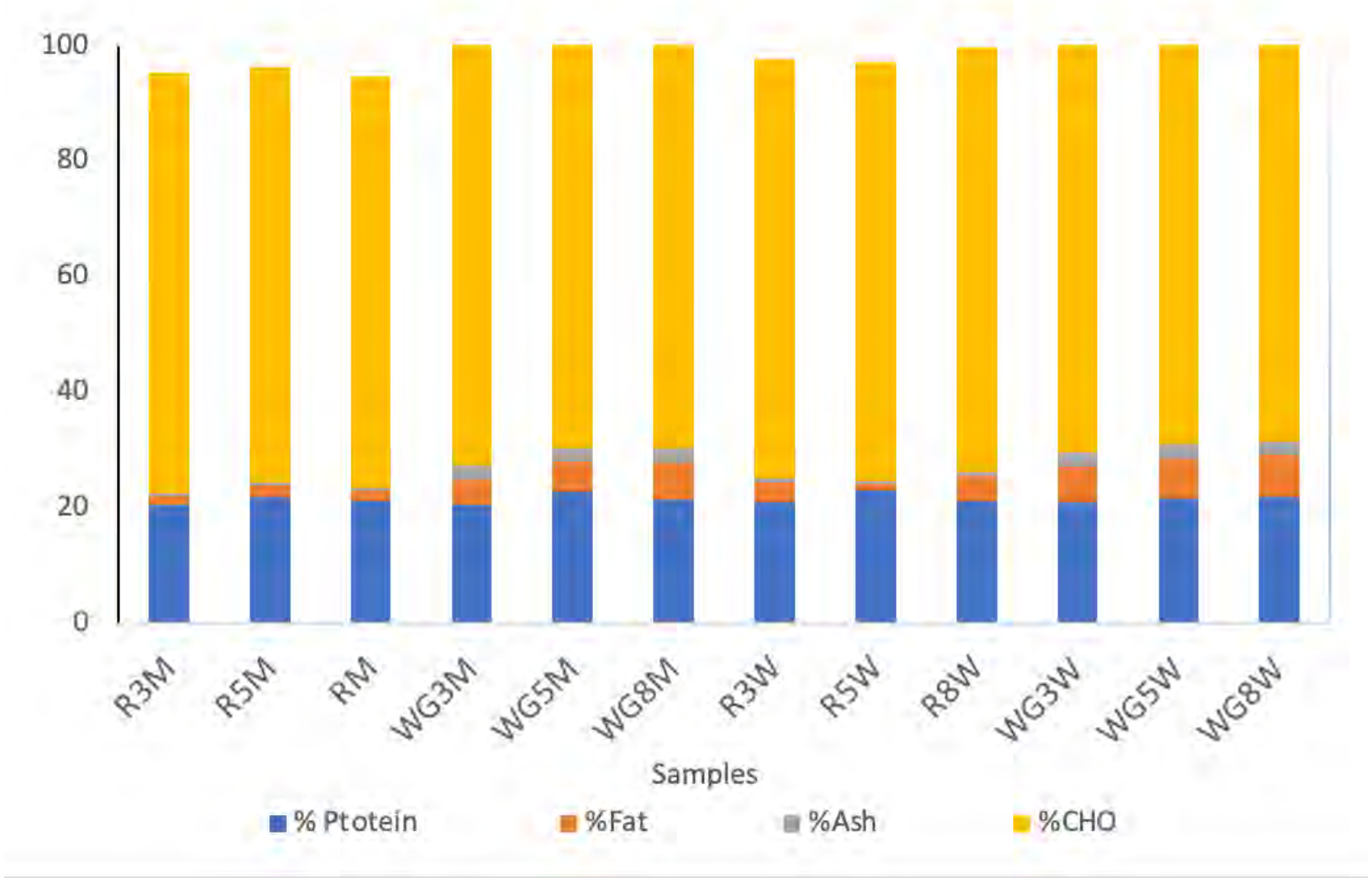
Refined samples: IWG grain were tempered and milled with Brabender Quadrumat Junior Mill

Chemical composition: Determined using standard methods

Pasting properties: Evaluated using the Micro Visco – Amylo - Graph

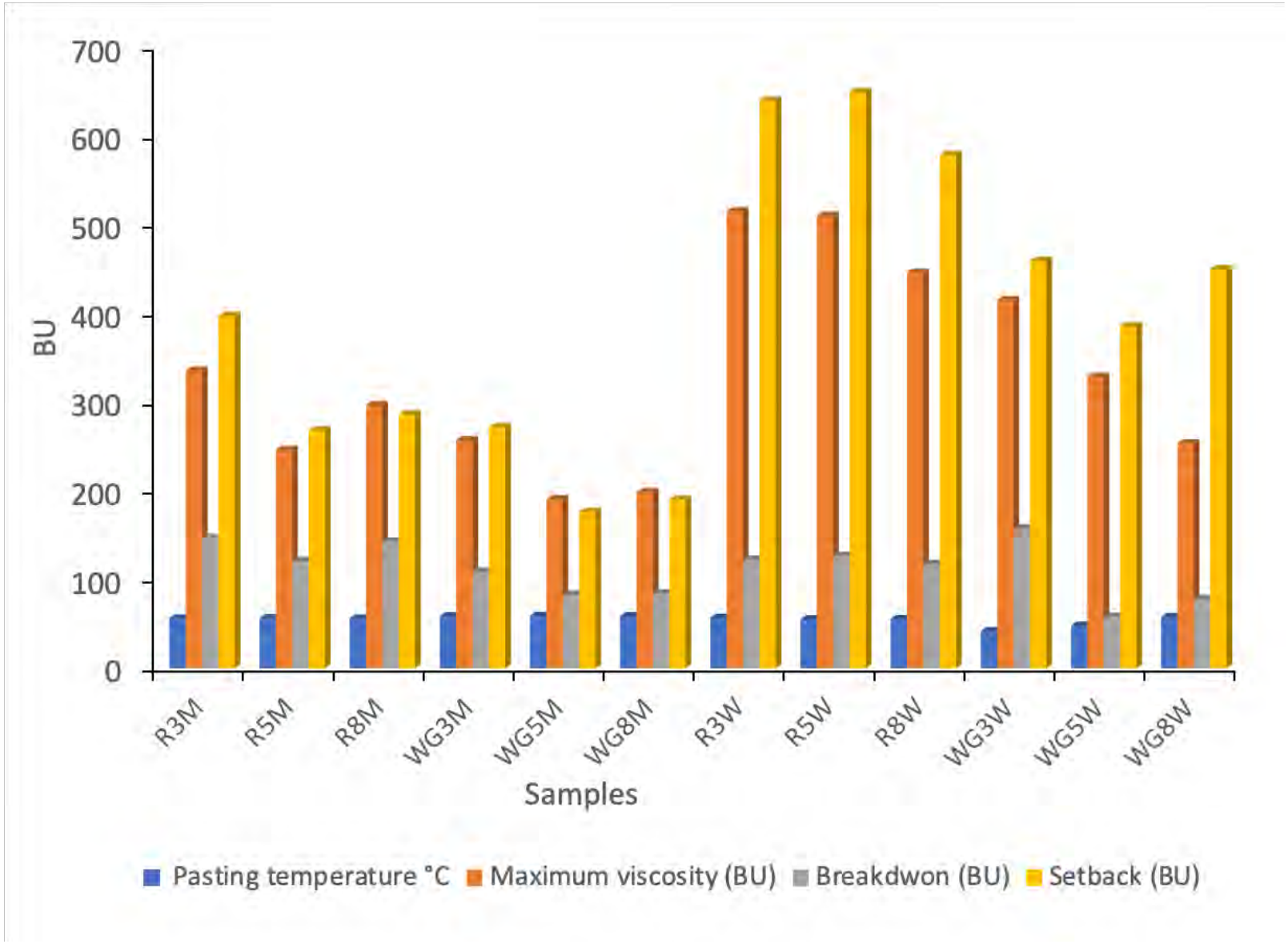
Results - Chemical composition

3-No nitrogen treatment
5-nitrogen treatment in the Spring
8-Nitrogen treatment in the Fall
M- Minnesota
W- Wisconsin
R - Refined
WG - Whole grain



Results - Pasting properties of nitrogen treated and untreated IWG

3-No nitrogen treatment
5-nitrogen treatment in the Spring
8-Nitrogen treatment in the Fall
M- Minnesota
W- Wisconsin
R - Refined
WG - Whole grain



Puffing Application of Kernza® Grain as a Food Ingredient

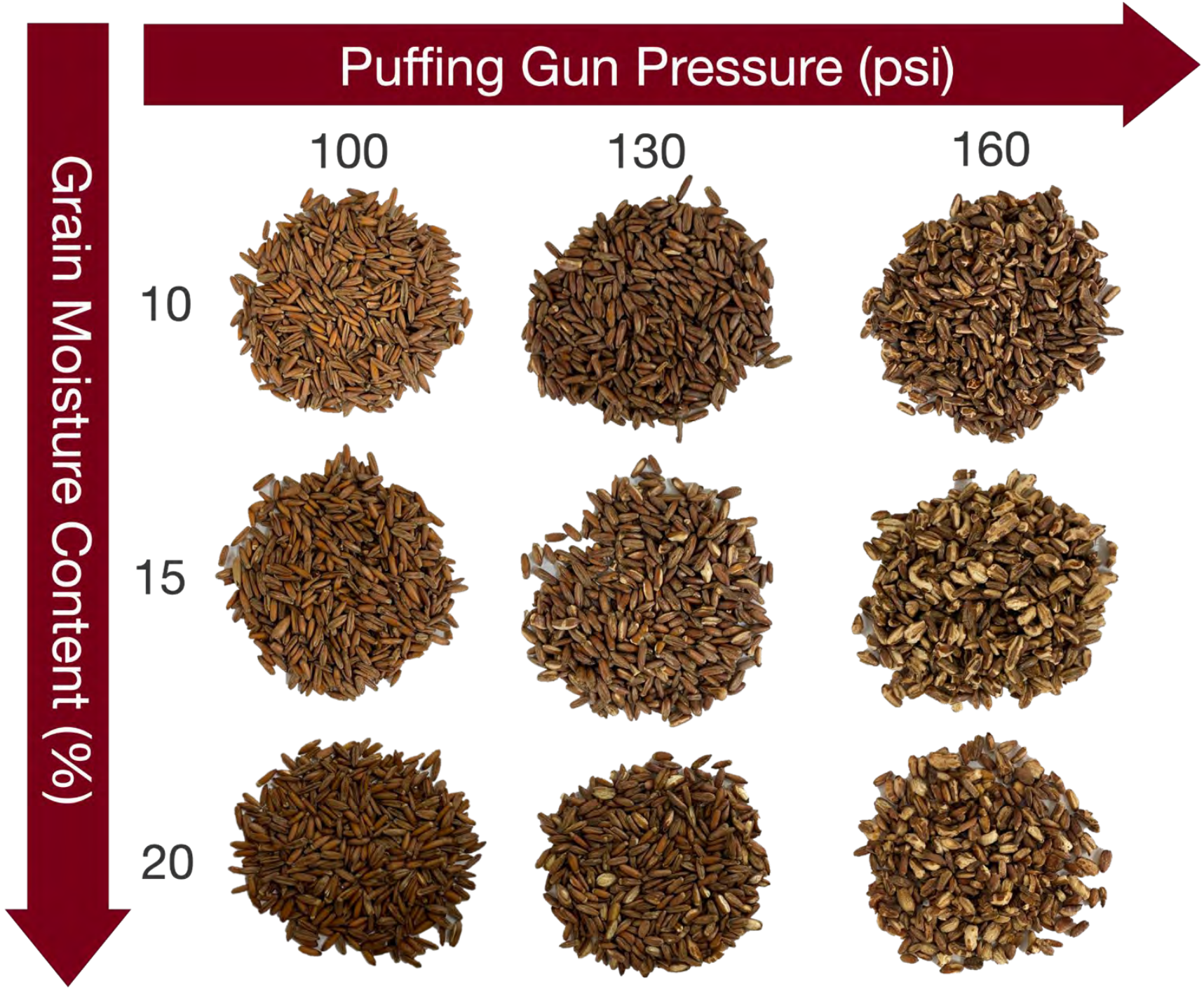
Dana Edleman, Food Science Graduate Student

Forever Green

University of Minnesota
Driven to Discover℠

Puffing

- Rapid application of heat and pressure allowing moisture in grain to vaporize and expand grain (Mariotti, 2005)
- RTE breakfast cereals & snacks


Puffing Gun Pressure (psi)
100
130
160
Grain Moisture Content (%)
10
15
20

Puffed Physical Analysis

Grain Moisture (%)	Pressure (psi)	Kernel Water Uptake (%)	Puffed Kernel Ratio (%)	Bulk Density (g/L^3)	Color Lightness (L*)	Color Red/Green (a*)	Color Yellow/Blue (b*)
10	100	58.01± 8.20	0 ± 0	603 ± 18	43.57 ± 2.12	7.34 ± 0.60	12.39 ± 0.69
	130	82.19 ± 6.86	8 ± 3	417 ± 8	41.74 ± 0.97	6.30 ± 0.33	10.44 ± 0.60
	160	219.29 ± 15.79	87 ± 3	250 ± 7	44.56 ± 1.54	5.36 ± 0.48	11.36 ± 1.55
15	100	57.89 ± 5.71	1 ± 1	550 ± 22	43.52 ± 1.00	7.42 ± 0.40	13.45 ± 0.83
	130	103.64 ± 8.99	23 ± 7	380 ± 10	43.45 ± 0.22	6.90 ± 0.49	12.06 ± 0.64
	160	260.70 ± 33.62	89 ± 9	193 ± 3	44.78 ± 1.83	5.52 ± 0.66	12.09 ± 1.83
20	100	67.53 ± 9.74	3 ± 1	524 ± 15	43.23 ± 1.03	7.29 ± 0.47	14.18 ± 1.13
	130	106.73 ± 8.73	46 ± 5	374 ± 11	44.45 ± 0.90	7.04 ± 0.48	14.12 ± 0.43
	160	221.49 ± 13.33	92 ± 2	238 ± 3	43.77 ± 1.26	6.19 ± 0.46	12.42 ± 1.17

Improving the nutritional profile of Kernza® by solid-state fermentation with Aspergillus oryzae strains

Takehiro Murai, Food Science Graduate Student

Forever Green

University of Minnesota
Driven to Discover℠

Fermentation with strains of *Aspergillus oryzae*

Analysis conducted/planned

1. Sugar content ☑
2. Amino acid content
3. Total phenolic content
4. Kojic acid content ☑
5. Antioxidant capacity
6. Total flavonoid content
7. Phenolic acid composition

https://www.realsimple.com/food-recipes/shopping-storing/beverages/what-is-sake

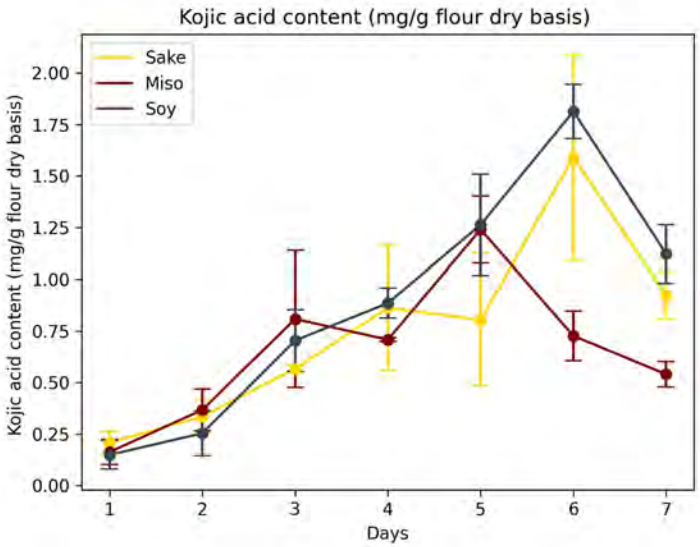
https://www.realsimple.com/food-recipes/shopping-storing/beverages/what-is-sake

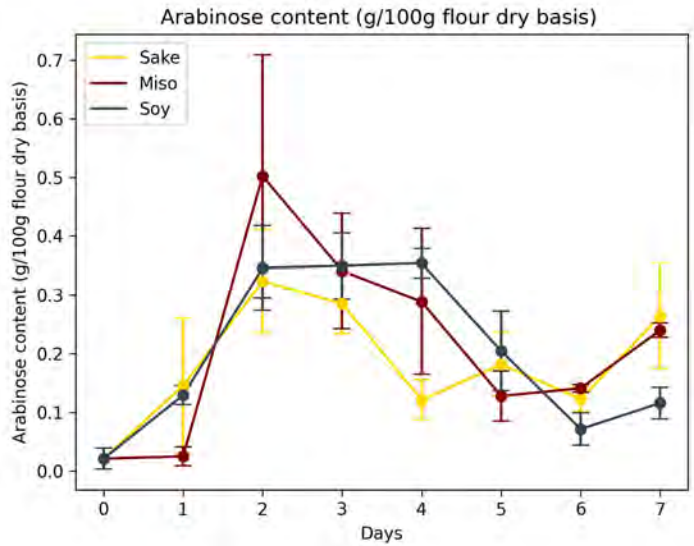
Kojic acid and sugar

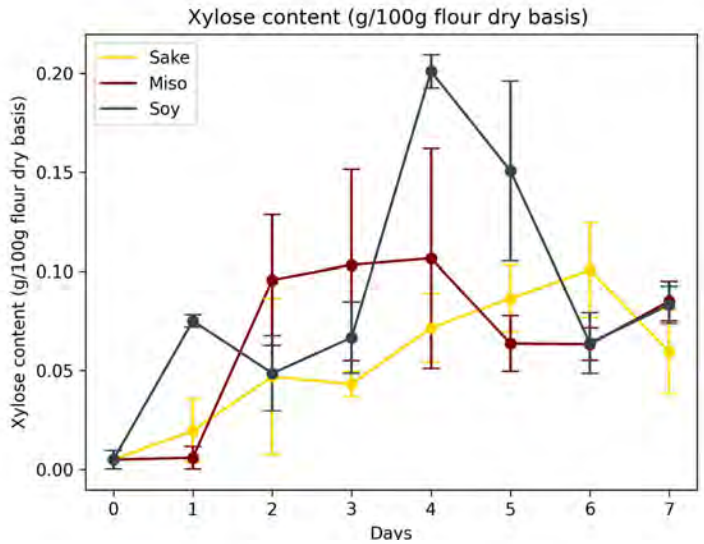
Strain	Day	Arabinose	Xylose	Glucose	Fructose	Sucrose
Sake	0	0.02	0.01	0.80	1.40	0.24
Sake	1	0.15	0.02	1.83	0.36	2.43
Sake	2	0.32	0.05	3.39	0.68	5.49
Sake	3	0.29	0.04	3.80	0.88	3.23
Sake	4	0.12	0.07	3.23	0.98	0.65
Sake	5	0.18	0.09	3.50	1.08	1.08
Sake	6	0.12	0.10	3.12	0.55	0.35
Sake	7	0.26	0.06	2.83	0.62	4.10
Miso	0	0.02	0.01	0.80	1.40	0.24
Miso	1	0.03	0.01	4.03	1.24	2.92
Miso	2	0.50	0.10	3.32	0.94	3.55
Miso	3	0.34	0.10	4.13	1.33	2.95
Miso	4	0.29	0.11	5.55	1.32	1.01
Miso	5	0.13	0.06	4.01	0.56	0.43
Miso	6	0.14	0.06	5.17	1.31	0.90
Miso	7	0.24	0.09	5.95	1.65	0.97
Soy	0	0.02	0.01	0.80	1.40	0.24
Soy	1	0.13	0.08	4.67	1.26	2.49
Soy	2	0.35	0.05	1.80	0.43	0.79
Soy	3	0.35	0.07	2.67	0.78	1.69
Soy	4	0.35	0.20	4.25	0.67	0.35
Soy	5	0.20	0.15	2.71	0.72	0.39
Soy	6	0.07	0.06	2.12	0.59	0.17
Soy	7	0.12	0.08	1.56	0.45	0.30

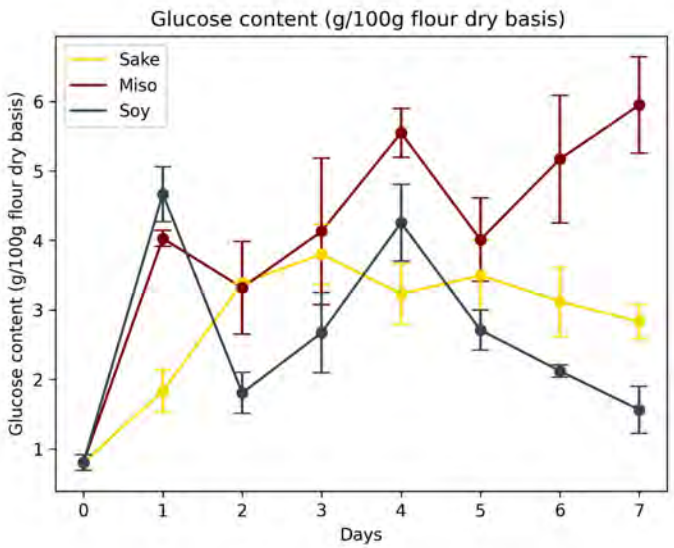
Units are in g/100g flour dry basis

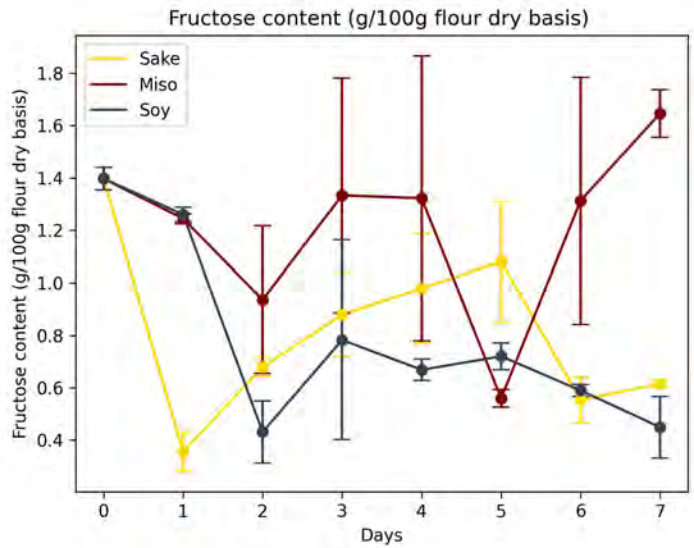
Kojic acid and sugar

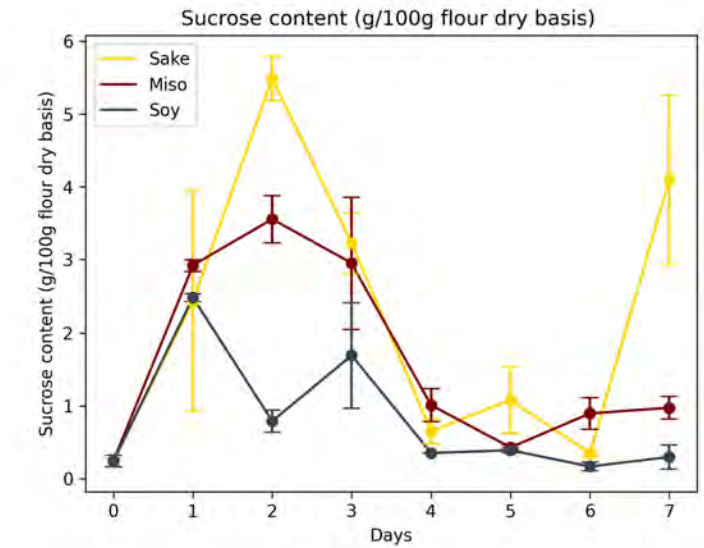












Kernza® Brewing and Malting Quality: Survey Results

Alison Hamm, PhD

USDA - ARS – Soil Management and Sugarbeet Research Unit

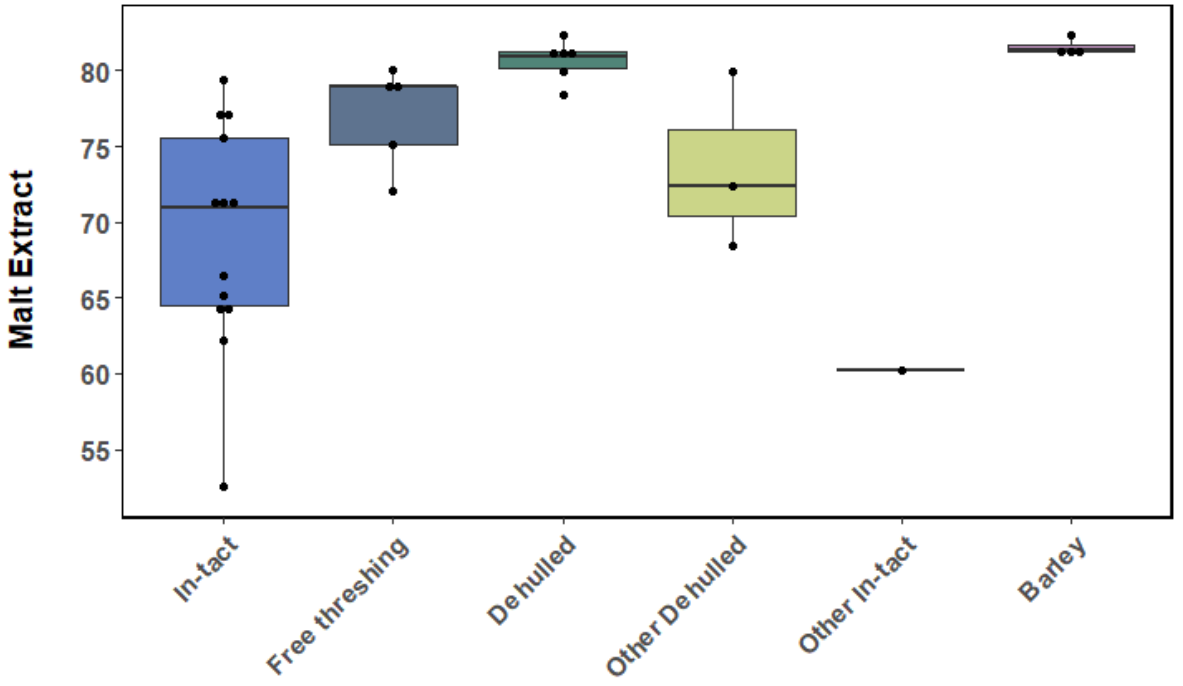
Fort Collins, CO

24 Kernza samples:

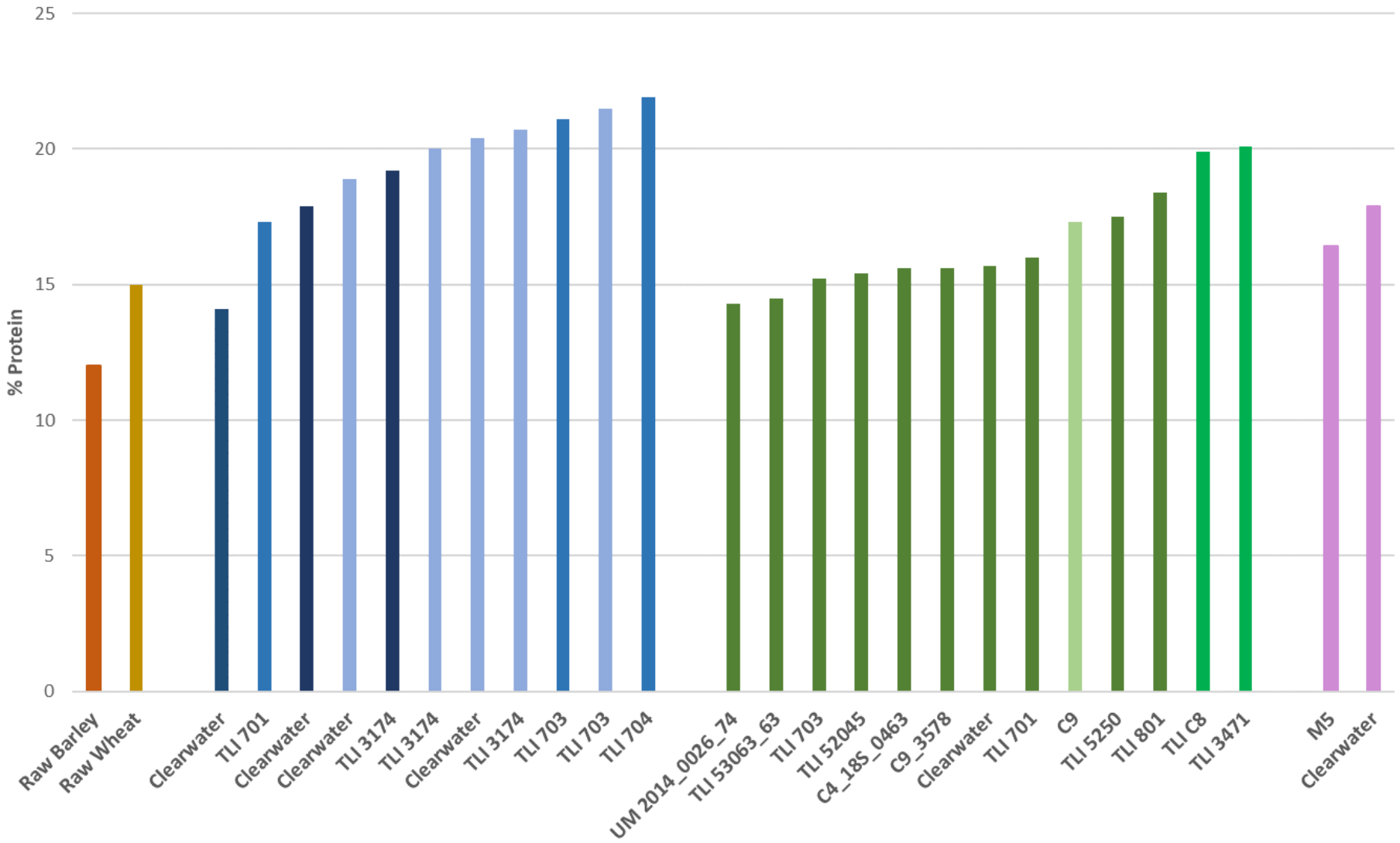
- 16 Varieties, 4 states
  - Commercial farms (11) and breeding plots (13)
- Dehulled (6), free-threshing (5), and in-tact (13)

Results Summary:

- Variability between varieties, growing locations and hull presence
- Some differences compared to other data available in the literature and online



Protein (Raw Grain)



Commercial Farms

- In-tact
- Free threshed
- Dehulled

Breeding plots

- In-tact
- Free threshed
- Dehulled

From Literature

- Dehulled

Should Kernza Be Dehulled Before Malting?

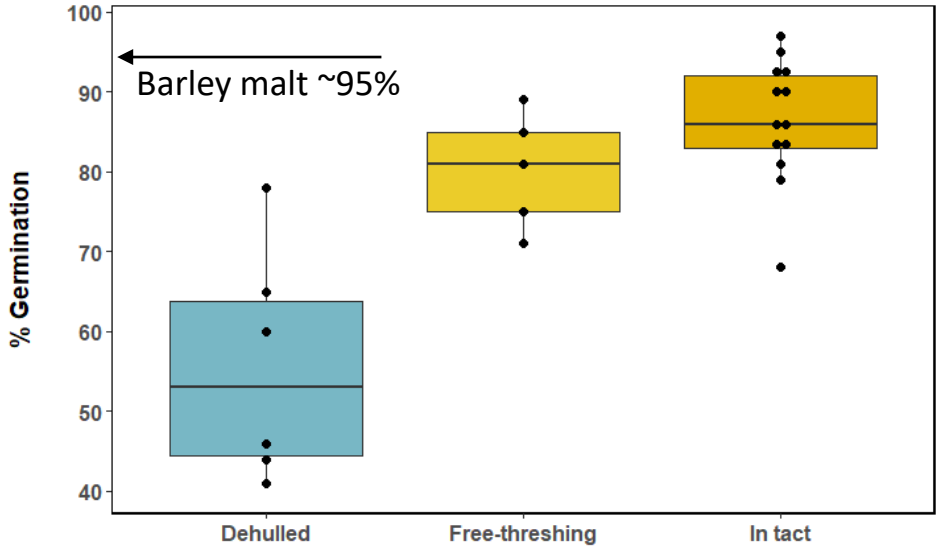
(barley isn't!)

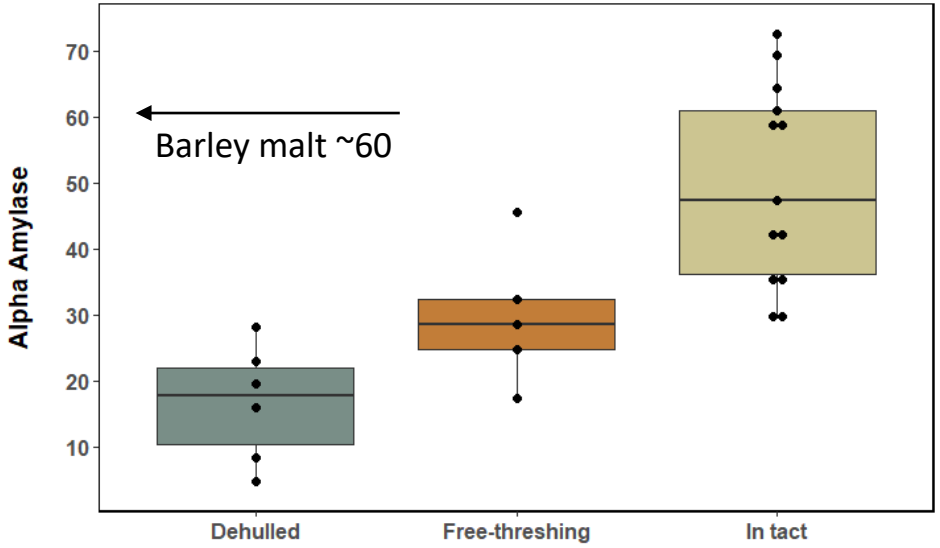
Dehulling pros:

- Increases bushel weight ~30%
- No added husk flavor
- Limit introduction of microbes and mycotoxins

Dehulling cons:

- More processing for the farmer
- Decreases α-amylase enzyme for starch conversion
- Brewery addition of filtration agent (rice hulls)
- Harder to malt
  - Decreases germination
  - Smaller seed size is difficult with equipment

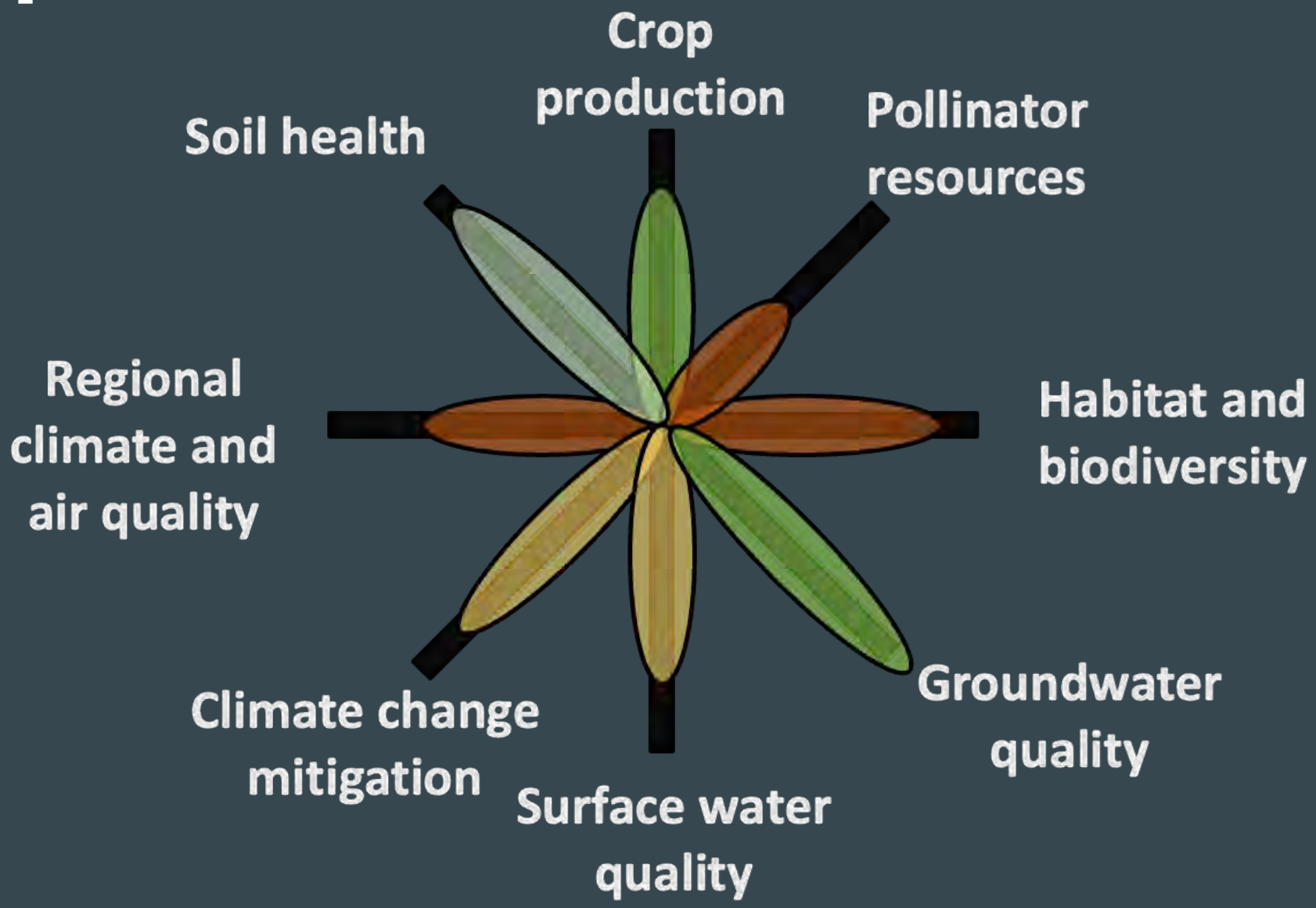




What do we know about the environmental impacts of Kernza?

Presenter: Jake Jungers, University of Minnesota
Slide prep: Jess Gutknecht and Jake Jungers University of Minnesota

A snapshot:


Crop production
Pollinator resources
Habitat and biodiversity
Groundwater quality
Surface water quality
Climate change mitigation
Regional climate and air quality
Soil health

What do we know? Water quality

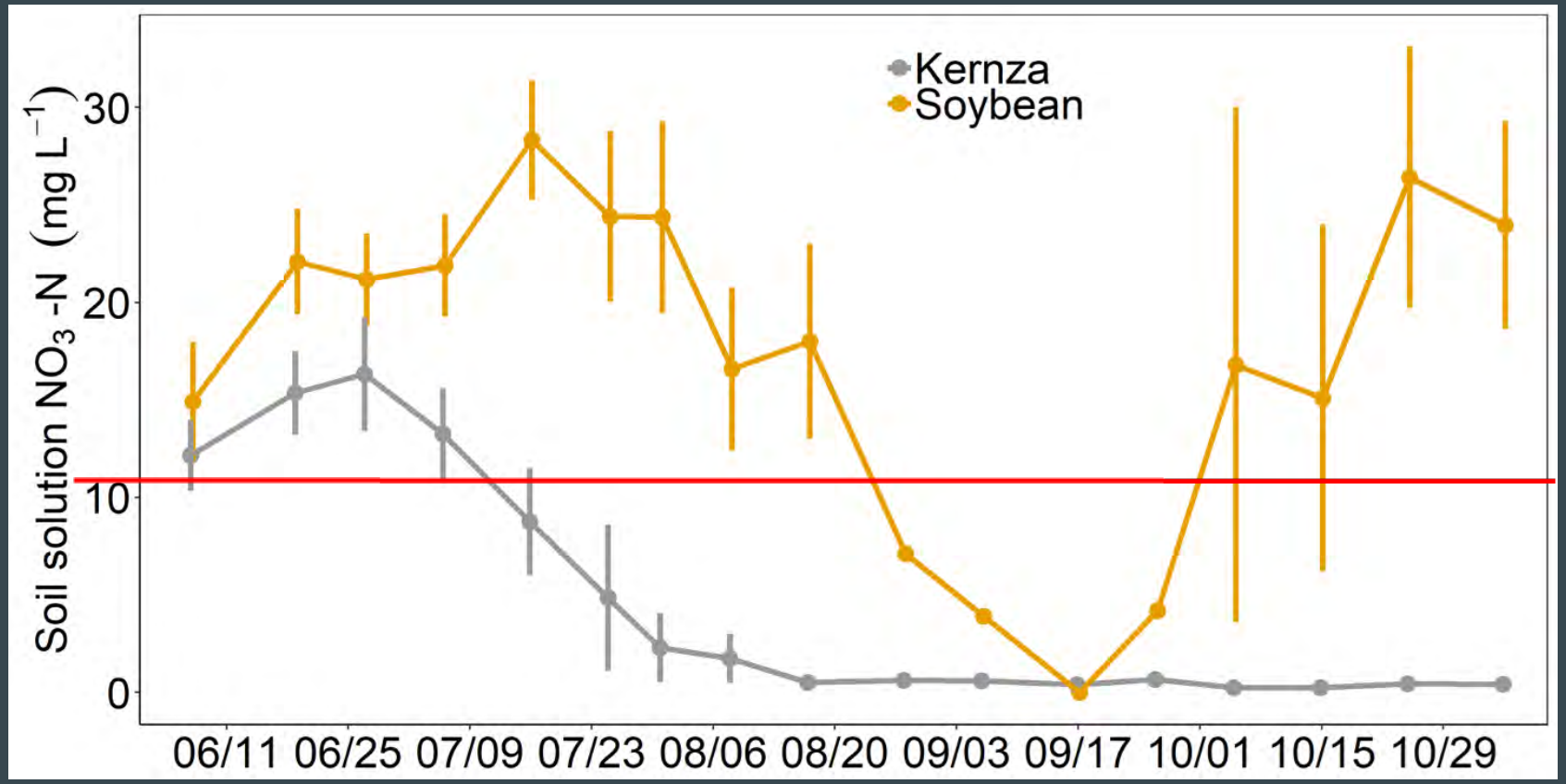
Kernza prevents nitrate leaching to groundwater.

Culman et al., 2013 - Wheat

Jungers et al., 2019 - Corn

Reilly et al., 2022 - Corn/soybean

Huddell et al., 2023 - Wheat

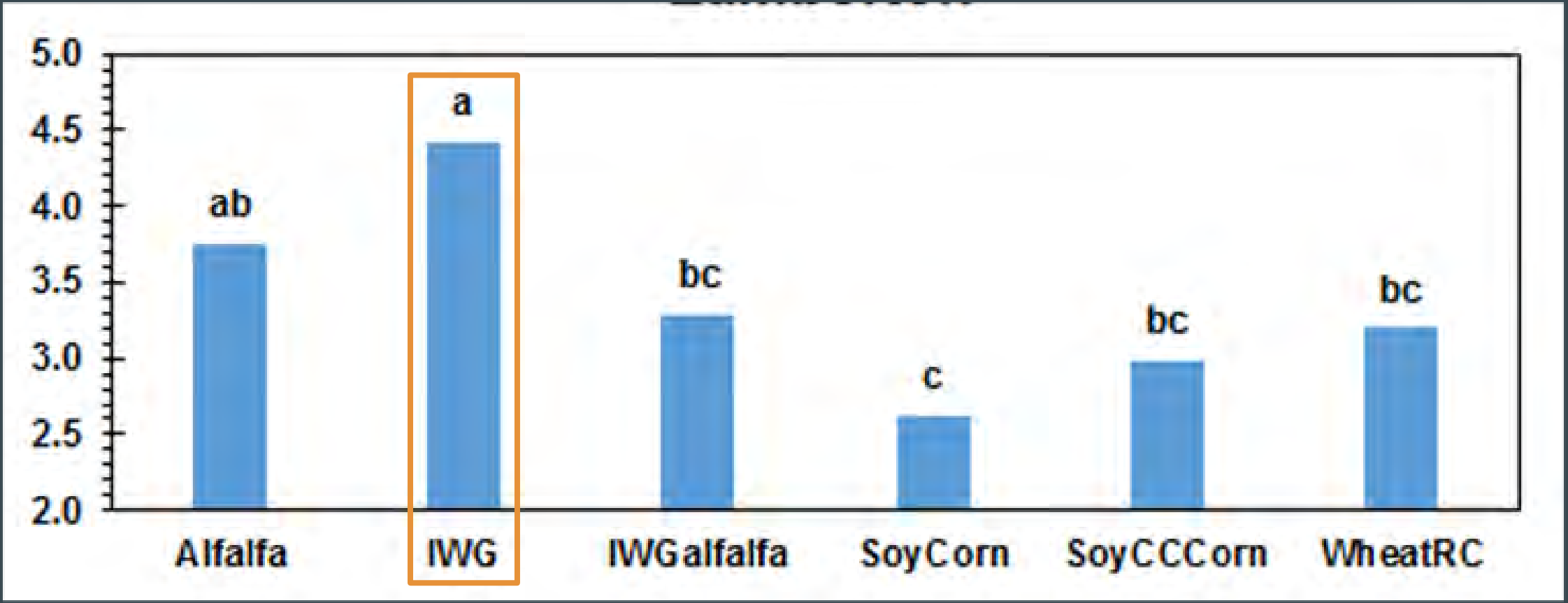


EPA drinking water limit, ~ 10 ppm

Reilly et al. 2022

What do we know? Soil and carbon

- Kernza quickly improves aggregate stability (~2 years; Rakkar et al. 2022; Link et al. 2023)



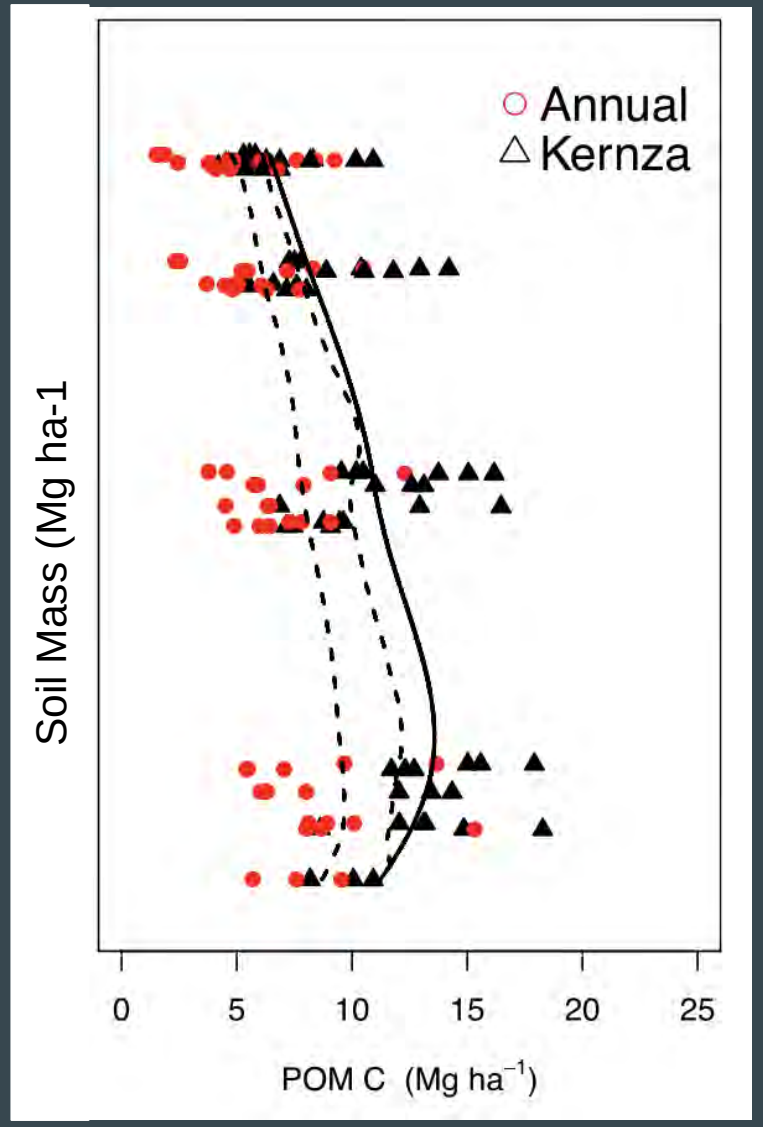
Bigger stable soil aggregates (Rakkar et al. 2022)

What do we know? Soil and carbon

- Kernza quickly improves aggregate stability (~2 years; Rakkar et al. 2022; Link et al. 2023)
- Kernza encourages microbial growth and AMF growth (McKenna et al., 2020; Audu et al., 2022; others)

What do we know? Soil and carbon

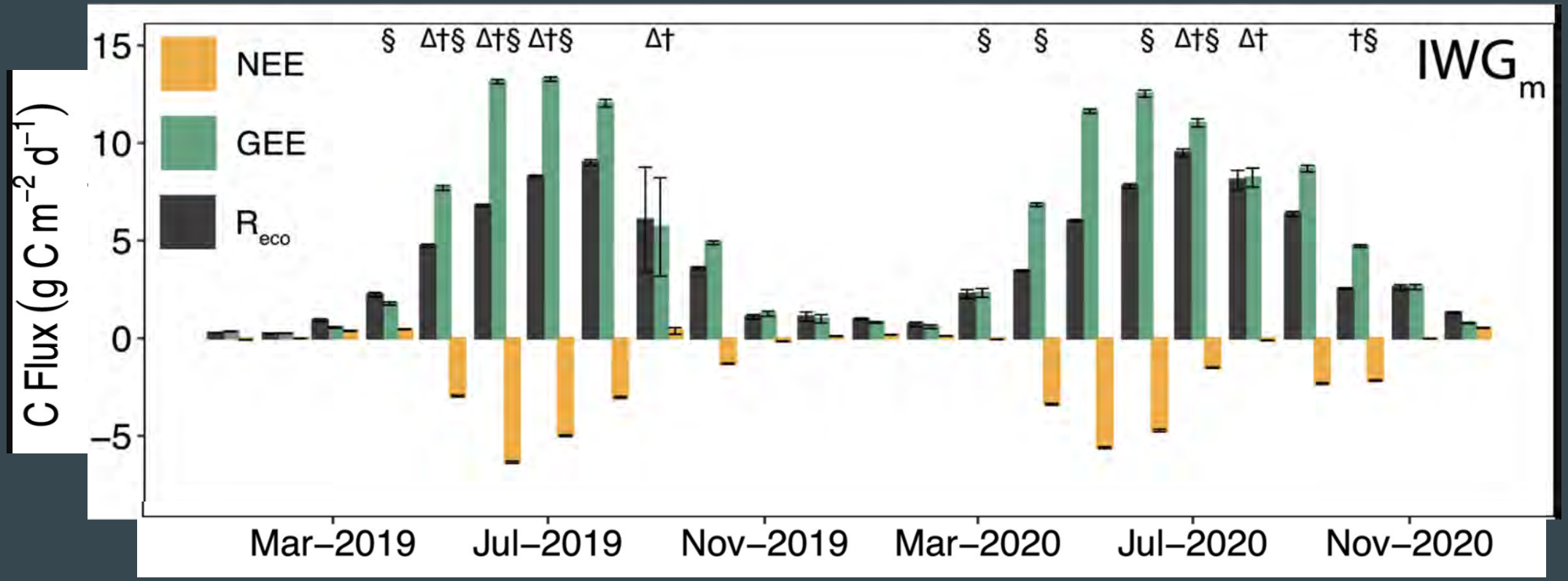
- Kernza quickly improves aggregate stability (~2 years; Rakkar et al. 2022; Link et al. 2023)
- Kernza encourages microbial growth and AMF growth (McKenna et al., 2020; Audu et al., 2022; others)
- Kernza may respire (lose) soil carbon after 1 year of growth (Woeljen et al. 2023) but in the longer term may store carbon deep in the soil (Van der Pol et al. 2022 and others)



More carbon deep in the soil (Van der Pol et al. 2022)

What do we know? Carbon balance

- Kernza can be a small positive ecosystem level carbon sink, but results are variable based on climate or fertilization needs; more studies in different environments and over different time frames are needed (Wiesner et al. 2022; de Oliveira et al. 2020).



Future Research

- Nitrate leaching across a broad range of soil types and climates
- Water conservation in arid regions
- Carbon footprint under varying management (e.g., dual-use)
- Nitrous oxide emissions
- Biodiversity and wildlife habitat
- Payments for ecosystem services

Future Research

- Nitrate leaching across a broad range of soil types and climates
- Water conservation in arid regions
- Carbon footprint under varying management (e.g., dual-use)
- Nitrous oxide emissions
- Biodiversity and wildlife habitat
- Payments for ecosystem services

EQ Breakout Session 3

Thanks!

USDA – ARS: Kernza® Initiative
Environmental and Ecosystem Services

Grace Miner - Soil and Sugarbeet Management Research Unit, Fort Collins, CO
Alison Duff – Dairy Forage Research Center, Madison, WI
Josh Gamble – Plant Science Research Unit, St. Paul, MN

KernzaCon June 22-23, 2023

KERNZA/IWG

Regional & National Assessment

Coordinated Temporal/Spatial Data

Production (G × E)

Forage quality/nutritive value

Grain yields, grain quality

End use

Brewing, baking quality

Environmental and Ecosystem Services

Soil health/Soil quality; Soil biology; Water

Attune to Agroecological Realities

Minimum common datasets related to soil sample collection, processing, chemical and physical properties, crop growth and development, yield components, and associated metadata.

Environmental and Ecosystem Services: WATER

Dryland and Irrigated Western Agroecosystems

- Water-use efficiency and precipitation use efficiency of Forage and Grain yield?
- **Water Use in-season vs water capture and storage? Drought tolerance?**
- Potential for reduced input costs, long-term environmental benefits, and potential dual-use
- **Improve Farm and Ranch Resilience**

Field Data to Inform the Integrated Farm System Model

José Franco, Alison Duff, and Al Rotz

How does intermediate wheatgrass (IWG) compare with other regional dairy forage systems in:

Productivity
Profitability
Carbon Balance
Fossil Energy Footprint

S1	Continuous corn silage (CCS)
S2	CCS + interseeded cover crops (CC)
S3	CCS + fall CC
S4	WW→sorghum sudan/CC mix→ corn silage→soybean
S5	Alfalfa
S6	IWG

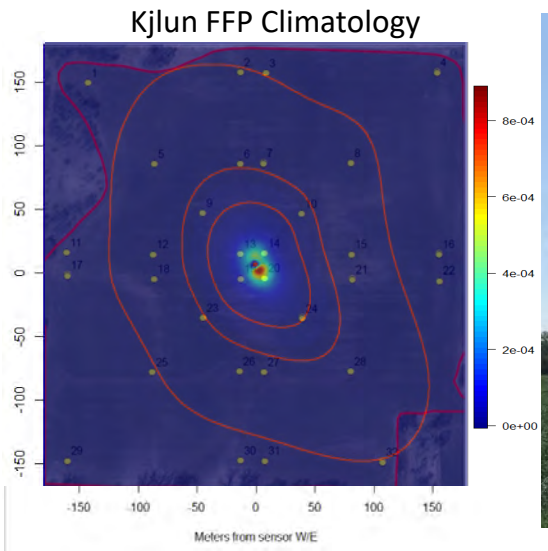
Carbon Balance of Forever Green Agroecosystems

Joshua Gamble, Jake Jungers, Jess Gutknecht, Ce Yang

Evaluating modes of continuous living cover (CLC) for improving C balance:

- **Field-Scale Productivity**
- **Reconciling C budgets (eddy flux, soil inventory, static chambers)**
- **Quantifying Spatial Variability**
  - **Carbon Balance & GHG Emissions**
  - **Soil Aggregate Stability & Enzyme Activity**
  - **Grain maturity**

Year	*Annual intensification CLC*	*Perennial CLC*
2020	Silage corn - Winter camelina	Alfalfa
2021	Winter camelina-Soybean (double)	Alfalfa
2022	Spring wheat-Winter camelina	Alfalfa-IWG ‘MN Clearwater’ (fall seeding)
2023	Winter camelina-Soybean (relay)	IWG ‘MN Clearwater’
2024 - 2026	…	…



Q&A

Presentation of 2023 Kernza Demand Review + Q&A

Kernza Market: 2023 Demand Survey Findings

A SUMMARY OF FINDINGS & NEXT STEPS

KernzaCON JUNE 2023 PRESENTATION

Goals

Gain insight into the successes and challenges of working with Kernza.

Methodology

Worked with our industry and research partnerships to compile a list of 80+ businesses working with (or interested in) Kernza.

Developed ~15 quantitative and qualitative questions, aimed at identifying market successes, challenges, and price sensitivity

Recipients

The survey was sent to anyone that had:

- cooked with Kernza at an event,
- received a kernza sample or piloted a recipe,
- developed a Kernza product,
- or, is currently selling or developing Kernza products.

Response Rate

47% response rate!

Respondent business type:

- CPG Manufacturer
- Restaurant
- Other (generally brewery/ distillery)
- Processor
- Bakery
- Distributor

People recognize and appreciate the inherent worth of Kernza.

"Using Kernza strongly aligns with our values... and we plan to continue to use it as much as we are able."

- Anonymous

"We're committed to making Kernza work, and are building our company around it. "

- Anonymous

"Kernza is amazing and we need to support it for many reasons including our planet. "

- Anonymous

Key Themes

Supply & Marketing Concerns

Industry Specific Resources

Scientifically supported claims

Pricing Insights

Supply & Marketing

- Guaranteed **long-term availability** of product
- Long-term **consistency in quality** and performance of the grain
- Lack of well-understood and **scientifically supported claims**

- Development of a **supply dashboard** (2023)
- Pursuit of a **Kernza® LCA** (2023/2024)
- Kernza **Quality Standards** (2023/2024)

Industry Specific Resources

- 33% of respondents want **recipe development** and testing information
- 70% of restaurants want support in **marketing products with 1 - 5% Kernza**
- 66% of CPGs and 100% of processors need more marketing and **storytelling** materials

TLI is working to create **industry - specific kits**.

We want to **equip businesses with tools** for:

- Consumer Education
- Targeting marketing strategies
- Industry specific recipes

Scientifically Supported Claims

Defensible and third-party verified claims around ecosystem benefits

- Provide **brands** with the data/claims they need to make climate-positive decisions
- Working towards carbon **insetting and offsetting** opportunities

TLI is working to identify partners to study and verify environmental claims:

- Pursuit of a **Kernza® LCA** (2023/2024)
- Third-party data collection: **biodiversity, water quality, carbon sequestration** (2023/2024)

Pricing Insights

When survey recipients were asked, "*Which of the following might help you move along the Kernza R&D journey?"*Most businesses selected:

A Reduction in Price

When survey recipients were asked, "*Thinking of the other ingredients which you purchase regularly, which is most similar in price/function to Kernza?"* We heard (and many more):

"Locally milled...organic spelt flour, finely milled..."

"Kernza is the only expensive grain that I purchase. I use ancient grains such as rye, turkey red, red fife, [and] buckwheat..."

"Other high-quality flours, such as King Arthur, Bob's Red Mill, Great River Milling, Sunrise Flour Mills heritage flours..."

Pricing Research

Van Westendorp Pricing Results*

Kernza	Theoretical Price Range*	N
Whole Grain	2.00 $/lb -- 3.00 $/lb	26
Flour	1.84 $/lb -- 3.00 $/lb	16

* This methods is NOT based on actual purchase data! These price ranges are based on buyer sentiment and perceived willingness to pay

Pricing Research

Kernza	Theoretical Price Range	Actual	Spelt	All Purpose Whole Grain Wheat (HRW)	Organic Einkorn
Whole Grain	2.00 $/lb -- 3.00 $/lb	2.5 $/lb	2.28 $/lb -- 2.80 $/lb	2.00 $/lb - 2.76 $/lb	4.52 $/lb -- 5.04 $/lb
Flour	1.84 $/lb -- 3.00 $/lb	4.5 $/lb	1.10 $/lb -- 2.20 $/lb	1.25 $/lb -- 3.53 $/lb	3.80 $/lb -- 4.30 $/lb

Estimated price ranges provide a wide window. To narrow the ideal price window, more **industry-specific pricing research is needed.**

Where to go from here:

Industry Specific Kits

Perennial Pricing Expiriment

Marketing & Storytelling

Specific Claims

Thank you!

Hana Fancher
Fancher@landinstitute.org
landinstitute.org

Lightning Talks #2

Education: Kernza® in Context

Aubrey Streit Krug & Lydia Nicholson

The Land Institute

kernzaincontext@landinstitute.org

Kernza®CAP

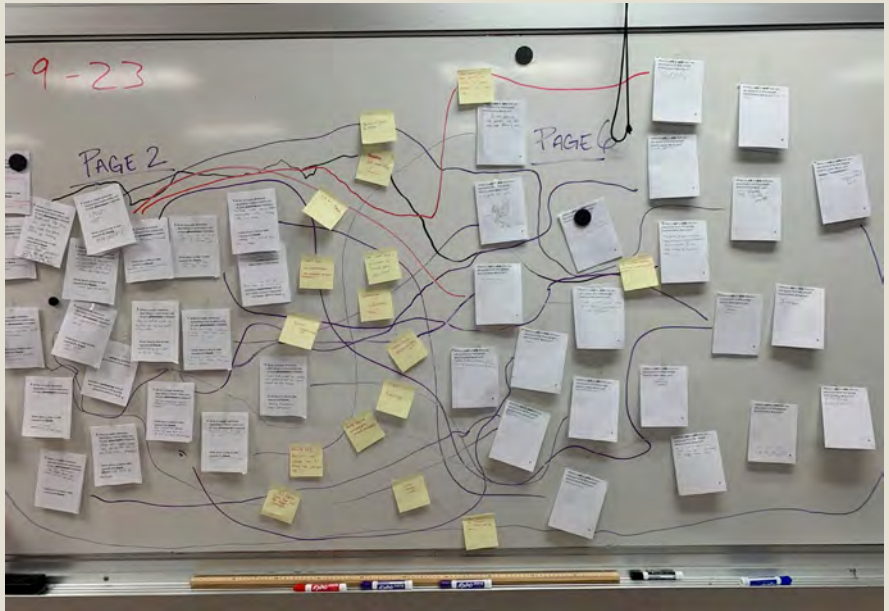
This work is supported by AFRI Sustainable Agricultural Systems Coordinated Agricultural Program (SAS-CAP) grant no. 2020-68012-31934 from the USDA National Institute of Food and Agriculture.

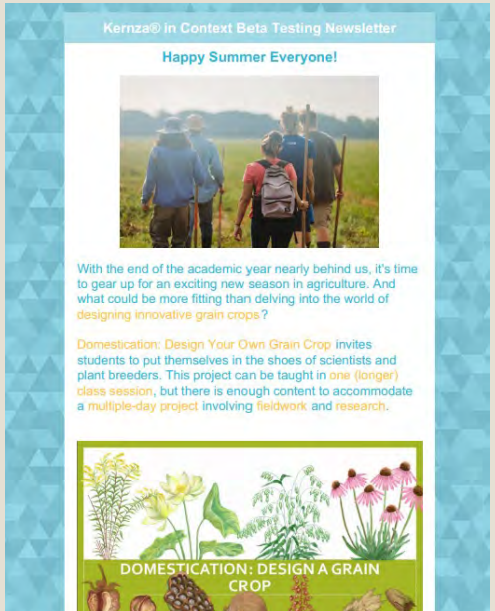
What is Kernza® in Context?

- Educational curriculum that we are developing to support students and teachers to learn about Kernza perennial grain in the context of their communities, agroecosystems, and planetary systems.
- Nearly 30 lessons drafted so far on a range of topics that align with high school standards in subject areas including science, history, and English
- Collaborative effort with many lesson designers, writers, and reviewers, from post-baccalaureate researchers and graduate students to teacher-researchers in the Kernza®CAP to high school and college teachers

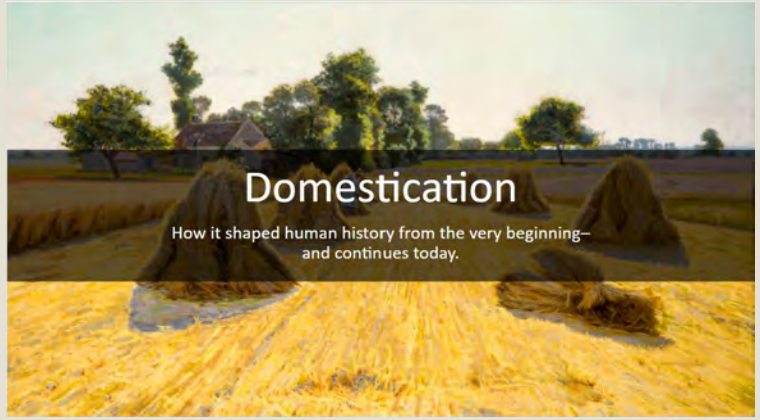
What is next for Kernza® in Context?

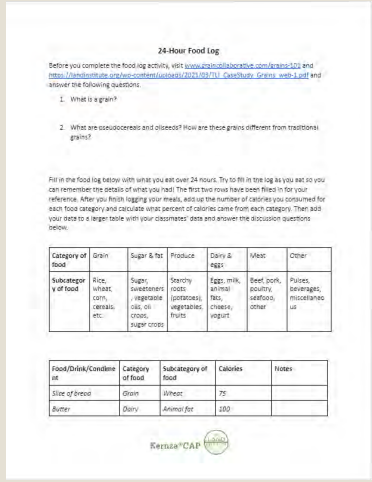
- Keep growing the beta-testing network and receiving feedback through individual teachers and group events, including organizations of high school teachers of science, agriculture, and environmental education
- Collaborate with UW-Madison agroecology educators to evaluate draft lessons and the framework, and then move into last phase of lesson development and revision
- Develop additional lessons, including on complex topics that may be more appropriate for undergraduate students
- Develop the publication format and dissemination plan – curriculum will be freely available!





How can Kernza® in Context be used?





24-Hour Food Log

Before you complete the food log activity, visit www.grainscollaborative.com/grains-101 and https://landinstitute.org/wp-content/uploads/2021/03/TLI_CaseStudy_Grains_web-1.pdf and answer the following questions.

1. What is a grain?
2. What are pseudocereals and oilseeds? How are these grains different from traditional grains?

Fill in the food log below with what you eat over 24 hours. Try to fill in the log as you eat so you can remember the details of what you had! The first two rows have been filled in for your reference. After you finish logging your meals, add up the number of calories you consumed for each food category and calculate what percent of calories came from each category. Then add your data to a larger table with your classmates' data and answer the discussion questions below.

Category of food	Grain	Sugar & fat	Produce	Dairy & eggs	Meat	Other
Subcategory of food	Rice, wheat, corn, cereals, etc.	Sugar, sweeteners, vegetable oils, oil crops, sugar crops	Starchy roots (potatoes), vegetables, fruits	Eggs, milk, animal fats, cheese, yogurt	Beef, pork, poultry, seafood, other	Pulses, beverages, miscellaneous

Food/Drink/Condiment	Category of food	Subcategory of food	Calories	Notes
Slice of bread	*Grain*	*Wheat*	*75*	
Butter	*Dairy*	*Animal fat*	*100*	

Kernza®CAP

Name_____

DATA Nugget

Collaborative cropping: Can plants help each other grow?
Featured scientist: Jake Jungers (he/him) from the University of Minnesota
Written by Claire Wineman (she/her)

Research Background

Most of the crops grown on farms in the United States are annual plants, like corn, soybeans, and wheat. **Annual** plants die every year after harvest and must be replanted the following year. Preparing farm fields for replanting every year can erode soils and hurt important bacteria and fungi living in the soil.

One way to change how we produce food is to grow more perennial crops. **Perennial** plants live for many years and don't need to be replanted. Perennials stay in the ground all year and start growing right away in the spring before annual crops are even planted. This early growth also gives perennial crops a "head-start" in competing with annual weed species that emerge later in the season.

While there are potential benefits of perennial crops, they are not commonly planted because they tend to make lower profits for farmers than annual crops. Crop scientists are still examining potential options to make perennial crops work at a large scale for farmers. For twenty years, researchers at The Land Institute in Kansas and at the University of Minnesota have been looking at a new perennial grain, called **Kernza®**, that could be used as an alternative to wheat and rye annual crops. Kernza® comes from the seeds of a plant called intermediate wheatgrass. Because Kernza® is such a new crop, scientists still have a lot to learn about it. Before it can be widely used by farmers, they want to know what field conditions help the plants grow to ensure the crop makes money for farmers.

Jake raking a soil core in a Kernza® field.

One strategy to improve field conditions for perennial crops is to plant **legumes** in the field alongside them. Legumes can make nitrogen, a nutrient that plants need to grow, more available to the plants around them. Additionally, farmers can select legume species that typically don't compete with the crop but may outcompete weeds.

Data Nuggets co-developed by Michigan State University scientists and teachers in the GK-12 Partnership.

Kernza® and Global Supply Chains

Lesson: Kernza® and Global Supply Chains

Driving Question(s): What are the components of a supply chain? What is the impact of supply chains beyond the products that they create?

Kansas History, Government, and Social Sciences Standards:
KHGSSS 1.1 The student will recognize and evaluate significant choices and consequences that have impacted our lives and futures. *Students learn the basics of a supply chain and how end products are the results of a multitude of choices. But the product of a supply chain is not its only consequence.*
KHGSSS 2.2 The student will analyze the context and draw conclusions about rights and responsibilities.
KHGSSS 2.4 The student will use their understanding of rights and responsibilities to make a claim or advance a thesis using evidence and argument.

Minnesota K-12 Academic Standards in Social Studies: 9.X.4.5.1 Substrand 4: Microeconomic Concepts Standard 5: Individuals, businesses, and governments interact and exchange goods, services, and resources in different ways and for different reasons; interactions between buyers and sellers in a market determine the price and quantity exchange of a good, service, or resource.

KSDE TASN:
I. Core Principles
B. Develop, implement, promote, and model core ethical and performance principles.
1. Analyze community needs in the larger community, analyze effects on the local and larger community, design, and critique positive, responsible action, and reflect on personal and community involvement.
2. Analyze ethical dilemmas in content areas and/or daily experiences

Section Goals
Students Will:
- Learn about how vast supply chains are and all the sectors they affect
- Learn the particular importance of food supply chains

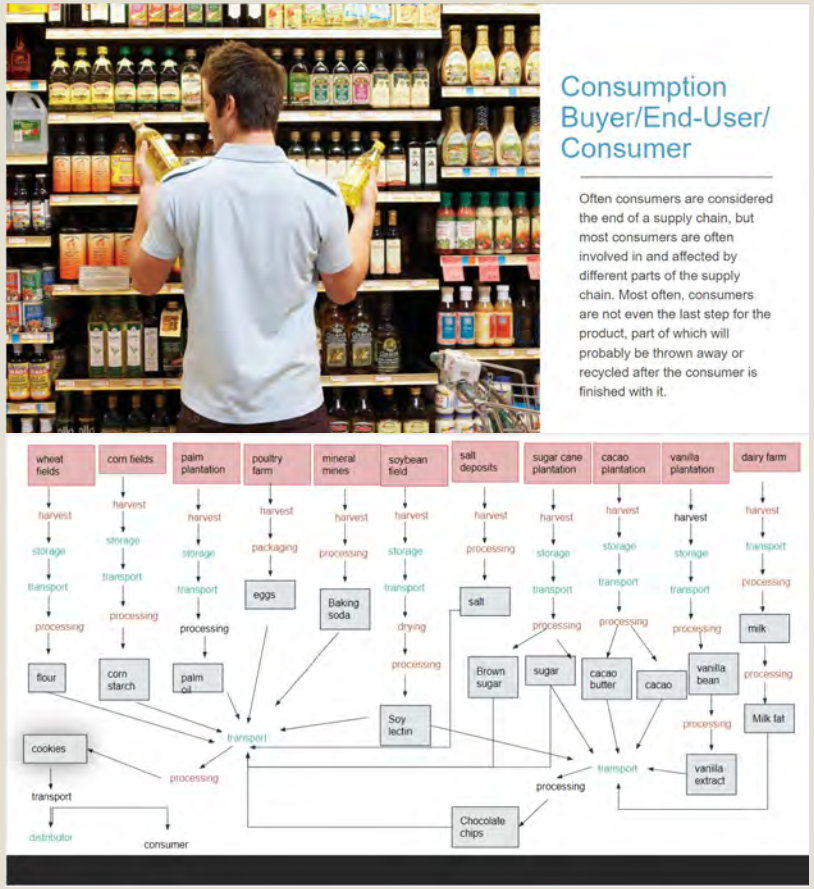
Section Objectives
Students Will be able to:
- Identify and briefly describe the three main parts of a supply chain.
- Express their views and opinions through discussion and argue for them using points from the reading they have previously summarized in question answers.
- Organize different supply chain activities by whether they are production, manufacturing, or distribution.

Lesson
If the class is unfamiliar with Kernza®, start by watching the Kernza® in Context video that can be found in the resource folder. Next, introduce supply chains with the PowerPoint Provided: Global Supply Chains in Context.pptx . This material can also be covered in Supply Chain Elements.pdf . After being introduced to the Famous Amos cookies, students will be able to begin the activity portion of the lesson. Divide the students into small groups, and assign each group one of the ingredients in the cookies. Each group should have a worksheet, the list of steps associated with their ingredient (out of order), scissors, glue, and something to write with. Each group should also receive the list of links associated with their ingredient. Set aside some time for the groups to research their ingredients and fill out the worksheets. Once all the groups have completed their worksheets come back together as a class to finish the PowerPoint. Have each group briefly summarize what they learned about their ingredient, then finish the PowerPoint together. If time allows, finish the class by watching at least the first 6 minutes of the Unbroken Ground documentary as an example of how new food supply chains are being developed.
Unbroken Ground | A New Old Way to Grow Food
Activity type: In-class lecture and discussion; in-class research; cut and paste activity sheet
Teacher prerequisite: Understanding of basic supply chains
Student prerequisite: None
Materials needed: Digital presentation, Activity Sheets, Scissors, Glue, pen or pencil.
Time to set up: 10 minutes for prepping activity
Time to teach: 40-90 minutes
Assessment type: Activity Sheets

This educational effort, Kernza® in Context, is being made possible through the support of the Agriculture and Food Research Initiative's (AFRI) Sustainable Agricultural Systems Coordinated Agricultural Program (SAS-CAP) grant no. 2020-68012-31934 from the USDA National Institute of Food and Agriculture (NIFA), known as the Kernza® CAP.

Kernza® CAP

Kernza® and Global Supply Chains



Cookie Supply Chain Resources

Distribute this list of links to students or groups to construct a supply chain for chocolate chip cookies. Most ingredients also have links to articles discussing ethical dilemmas around the products. Each ingredient has two articles that must be read (or skimmed) to complete the worksheet. One link will describe the supply chain, and one will address a moral controversy around the ingredient. Some ingredients have additional links that could be fun for students to explore or provide further supply chain context.

FLOUR

Necessary

What Is Monocropping and Why Is It Bad for the Environment? (treehugger.com)
This article briefly discusses the woes of monocropping, which is the method of growing nearly all wheat.

https://www.busbysbakery.com/how-is-flour-made/
This article clearly explains the steps in the flour-making process.

Supplementary

Wheat Supply Chain Data Collection (wa.gov)
This is a very long document showing the complexity level in wheat supply chains, even before grain becomes flour.

Microsoft PowerPoint - Day 2 Session 4 - Miller Milling (tortilla-info.com)
This source shows pictures of some of the equipment used in creating flour and a few maps showing where wheat is grown in the U.S.

https://hmhub.in/processing-wheat-flour/
This short video briefly goes over the flour-making process and history.

SOY LECITHIN

Necessary

Soybeans — Louisiana Ag in the Classroom (aitcla.org)
This page describes how soybeans are grown and processed and the history behind the plant. You only need to read about how soybeans are grown on this page. Once you reach the processing stage, switch to the following article.

How is Soy Lecithin Made? | National Lecithin
This page gives a simple break-down of how Soy Lecithin is made

The problem with soy | Forest 500
On this page, you can read about how soy farming in Brazil is threatening natural landscapes.

Supplementary

What Is Monocropping and Why Is It Bad for the Environment? (treehugger.com)
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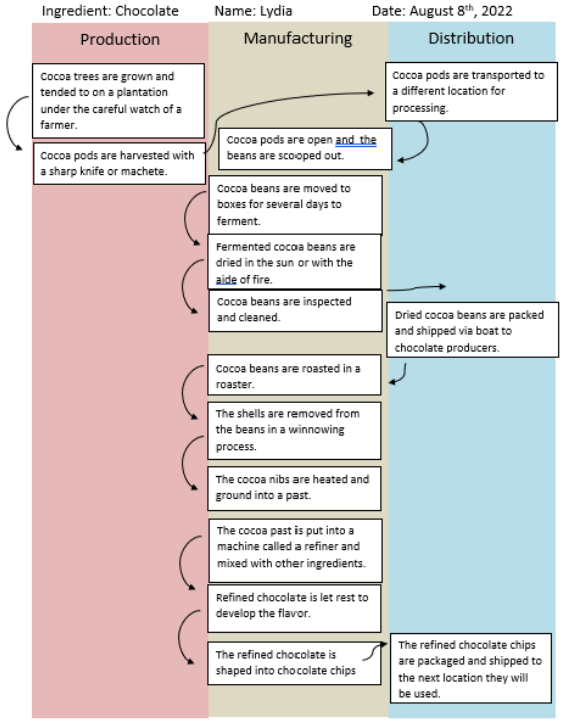

Other Lesson Types

Data Nuggets: Collaborative Cropping


DATA Nugget

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Featured scientist: Jake Jungers (he/him) from the University of Minnesota

Written by Claire Wineman (she/her)

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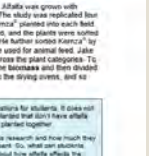
Most of the crops grown on farms in the United States are annual plants, like corn, soybeans, and wheat. **Annual** plants die every year after harvest and must be replanted the following year. Preparing farm fields for replanting every year can erode soils and hurt important bacteria and fungi living in the soil.

One way to change how we produce food is to grow more perennial crops. **Perennial** plants live for many years and don't need to be replanted. Perennials stay in the ground all year and start growing right away in the spring before annual crops are even planted. This early growth also gives perennial crops a "head-start" in competing with annual weed species that emerge later in the season.

While there are potential benefits of perennial crops, they are not commonly planted because they tend to make lower profits for farmers than annual crops. Crop scientists are still examining potential options to make perennial crops work at a large scale for farmers. For twenty years, researchers at The Land Institute in Kansas and at the University of Minnesota have been looking at a new perennial grain, called **Kernza®**, that could be used as an alternative to wheat and rye annual crops. Kernza® comes from the seeds of a plant called intermediate wheatgrass. Because Kernza® is such a new crop, scientists still have a lot to learn about it. Before it can be widely used by farmers, they want to know what field conditions help the plants grow to ensure the crop makes money for farmers.

One strategy to improve field conditions for perennial crops is to plant **legumes** in the field alongside them. Legumes can make nitrogen, a nutrient that plants need to grow, more available to the plants around them. Additionally, farmers can select legume species that typically don't compete with the crop but may outcompete weeds.


Jake taking a soil core in a Kernza® field.

Jake is an ecologist who uses his knowledge about plants to make agriculture more sustainable. Jake wanted to do some research into alfalfa, a type of perennial legume that might work well with Kernza®. Jake thought that growing alfalfa alongside Kernza® would lead to increased profit and yield for two reasons. One, because it would add nitrogen to the soil to boost crop growth. Two, because it would compete with agricultural weed species.

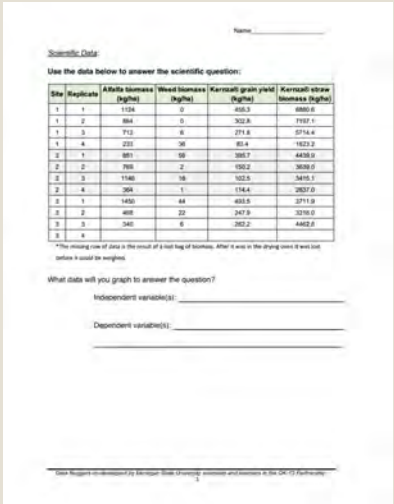
Teacher Note: One type of study that scientists use to learn about growing conditions is intercropping experiments, which involve growing two or more plants together. This type of study allows scientists to see whether there are benefits that the different plants provide to each other. Some of these benefits might include plants that have certain nutrients that are useful to another crop, or plants that suppress weeds by acting as groundcover.

To test this idea, Jake set up an experiment with his team. Alfalfa was grown with Kernza® at three different locations in Minnesota in 2019. The study was replicated four times at each site, with the same amount of alfalfa and Kernza® planted into each field. At the end of the growing season, the fields were harvested, and the plants were sorted into three categories: Kernza®, alfalfa, and weed species. He further sorted Kernza® by grain, which can be used for food, and straw, which can be used for animal feed. Jake wanted to compare yield, or plant growth per unit area, across the plant categories. To do this, he weighed all the plants in each category to get the **biomass** and then divided by the area of the field. One sample was lost on the way to the drying ovens, and so appears as blank cells in the table below.

Teacher Note: This experimental design may raise some questions for students. It does not have a control as students might expect - there are no fields planted that don't have alfalfa planted alongside Kernza®, only fields with the two perennials planted together.

Students can have a class discussion about the strength of this research and how much they can say based on the findings without data from a control present. So, what can students say from these data as they are? The scientist's question is about how alfalfa affects the growth of Kernza®. Though the same amount of seed was added to each site, variation did arise in the amount of alfalfa and Kernza® that grew at each site. This variability may be a result of several factors, including different soil types and weather conditions across the three locations in Minnesota. This variability also allows students to explore how the amount of alfalfa is related to the amount of Kernza®. Students can't be sure that high alfalfa drives high Kernza® - but they can say that there is a positive relationship between the two. To directly say how alfalfa affects Kernza®, there would need to be data to show how Kernza® performs at these sites without alfalfa present. As indicated in the next steps section, the scientists are looking at yields in fields with Kernza® monocultures to answer these questions.

The data in this activity is from 2019. This study was also replicated during two other growing seasons in 2017 and 2018.


Scientific Data:

Use the data below to answer the scientific question:

Site	Replicate	Alfalfa biomass (kg/ha)	Weed biomass (kg/ha)	Kernza® grain yield (kg/ha)	Kernza® straw biomass (kg/ha)
1	1	1124	0	458.3	6880.6
1	2	884	0	302.8	7197.1
1	3	712	6	271.8	5714.4
1	4	233	36	83.4	1623.2
2	1	951	19	386.7	4438.9
2	2	768	2	190.2	3639.0
2	3	1148	16	102.5	3455.1
2	4	364	1	114.4	2837.0
3	1	1450	44	493.5	2711.9
3	2	468	22	247.9	3216.0
3	3	340	6	262.2	4462.8
3	4				

*The missing row of data is the result of a lost bag of biomass. After it was in the drying oven it was lost (before it could be weighed).

What data will you graph to answer the question?

Independent variable(s): _____

Dependent variable(s): _____

_____

Data Nuggets co-developed by Michigan State University scientists and teachers in the GK-12 Partnership.

Projects: Design a Grain Crop


NELUMBO LUTEA

American Lotus

Number of perennial species: two

Soil Type: prefers rich and wet soils, it is an aquatic plant so it needs to be in water

Blooming and Seeding Time: Blooms in summer and into fall

Stratification or other treatment for planting: Before germinating a spot on the hard seed has to be ground down in a process called scarification.

Pests: Lotus do have some pests including several insects.

Known Negative Traits: Only grows in water.

Known Positive Traits: The Asian lotus species is extremely culturally important and popular as an ornamental plant and medicinal plant, so there is a lot of information about growth and care for the plant, down to details about the genome and seed processing for food.

Seed Size and Description: The seeds are fairly large, around six millimeters in length. It has a very hard outer coating.

3-6 feet tall

3-4 feet

Edibility: What parts are edible? The seeds and roots of this plant are considered edible.

What are traditional uses? Asian lotus have been used for many purposes including eating the raw seeds as a snack and grinding them into a past that can be used in pastries. The American species roots and seeds were both used in soups. The seeds were roasted and eaten.

Who has used it traditionally? Asian Lotus is popular throughout the continent, especially in china. American lotus has been used by the Comanche, Dakota, Huron, Mirokwaki, Ojibwa, Omaha, Pawnee, Ponca, Pinawaums, and winnebago peoples.

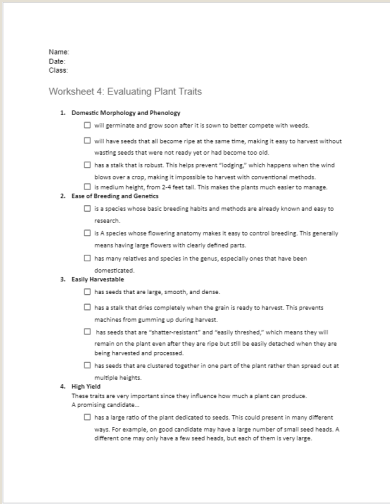
What desirable nutrients does it provide? The plant has many vitamins and minerals with well studied benefits.

How does it taste? The seeds are described as tasting pleasant and sweet.

Is it toxic? No

Is it related to edible or domesticated plants? The plant is not relaxed to any other grain crops, but the asian species has been domesticated horticulturally for a long time.

Ecosystem Services: Lotus plants attract pollinators, and as a native support the life cycles of native aquatic life.


Name:

Date:

Class:

Worksheet 4: Evaluating Plant Traits

1. **Domestic Morphology and Phenology**
   - ☐ will germinate and grow soon after it is sown to better compete with weeds.
   - ☐ will have seeds that all become ripe at the same time, making it easy to harvest without wasting seeds that were not ready yet or had become too old.
   - ☐ has a stalk that is robust. This helps prevent "lodging," which happens when the wind blows over a crop, making it impossible to harvest with conventional methods.
   - ☐ is medium height, from 2-4 feet tall. This makes the plants much easier to manage.
2. **Ease of Breeding and Genetics**
   - ☐ is a species whose basic breeding habits and methods are already known and easy to research.
   - ☐ is A species whose flowering anatomy makes it easy to control breeding. This generally means having large flowers with clearly defined parts.
   - ☐ has many relatives and species in the genus, especially ones that have been domesticated.
3. **Easily Harvestable**
   - ☐ has seeds that are large, smooth, and dense.
   - ☐ has a stalk that dries completely when the grain is ready to harvest. This prevents machines from gumming up during harvest.
   - ☐ has seeds that are "shatter-resistant" and "easily threshed," which means they will remain on the plant even after they are ripe but still be easily detached when they are being harvested and processed.
   - ☐ has seeds that are clustered together in one part of the plant rather than spread out at multiple heights.
4. **High Yield**

These traits are very important since they influence how much a plant can produce.

A promising candidate...

- ☐ has a large ratio of the plant dedicated to seeds. This could present in many different ways. For example, on good candidate may have a large number of small seed heads. A different one may only have a few seed heads, but each of them is very large.


Name:

Date:

Class:

Worksheet 3: Finding Your First Plants

In the field:

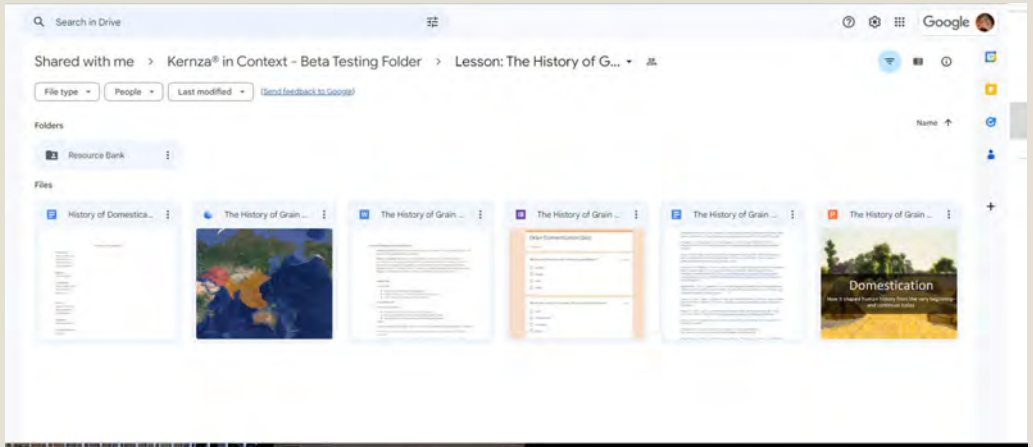
https://landinstitute.com/herbaceous-plants-vs-woody-plants/

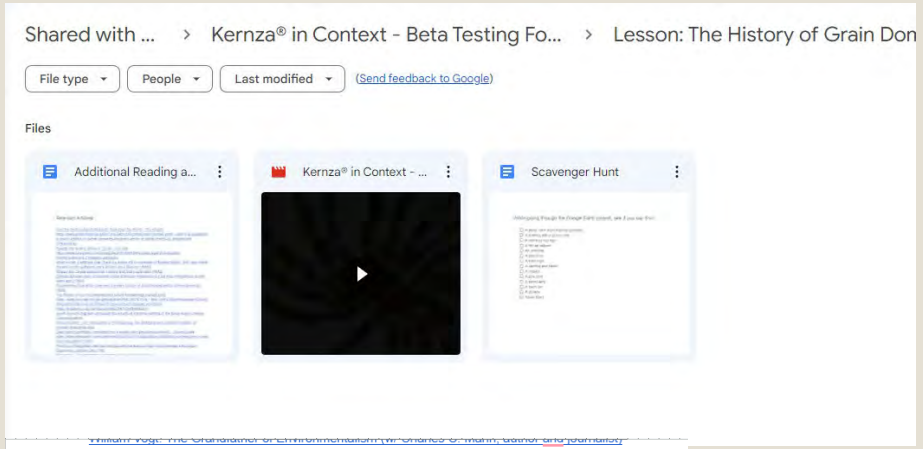
For this project, we are looking for plants that can be domesticated into grain crops. This means you will need to find **herbaceous seed-bearing** plants. During the fall it is easy to determine if a plant is seed-bearing; just look for seeds! If you are evaluating during a different season, look for flowers or green buds where seeds will be created. Deciding if it is herbaceous may be trickier. Herbaceous plants are distinguished from woody plants. The main difference is that herbaceous plant growth dies off during the colder months, while woody plants retain much of their above-ground growth. For example, deciduous trees and woody plants lose their leaves in the fall but retain their trunks and branches. An herbaceous perennial, such as coneflowers, may look like they also retain above-ground growth over the winter. A closer inspection, however, will reveal that the stems left above the ground are not alive, and the plant will have to grow new stems when spring comes. It is harder to tell the difference between herbaceous and woody plants in warmer climates. A good indicator is that woody plants tend to have inflexible stems covered in bark (that's what makes them woody), and herbaceous plants have much more flexible stems. Herbaceous plants are more likely to have green stems, whereas woody plants often have darker-colored stems due to their bark.

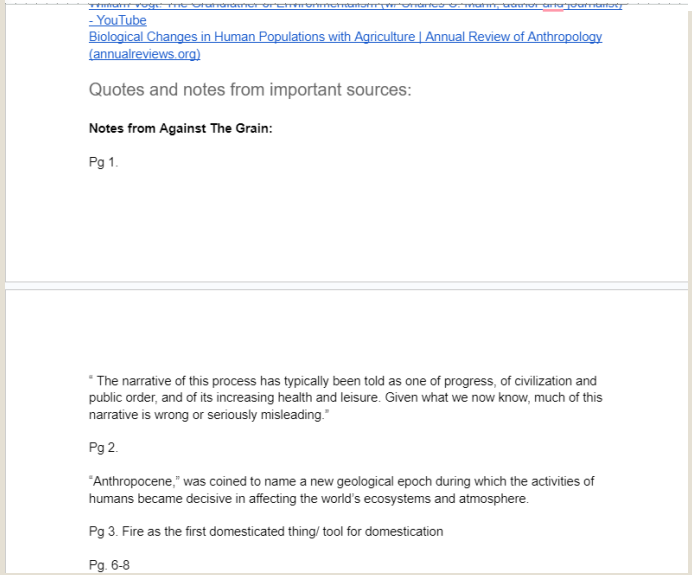
Choose a few wild plant species you can find outside that match your domestication goals. Make sure you can identify them to genus and make a good guess at species so you can look up information about them that you are not able to observe. You can use an app such as iNaturalist if you need to become more familiar with the plants in your area.

Once you have found the plants you would like to evaluate, look at the plant, and write the answer to these questions. These will help you fill out your plant profile and evaluate its domestication traits.

Using Lessons for More Advanced Audiences






- YouTube
Biological Changes in Human Populations with Agriculture | Annual Review of Anthropology (annualreviews.org)

Quotes and notes from important sources:

Notes from Against The Grain:

Pg 1.

" The narrative of this process has typically been told as one of progress, of civilization and public order, and of its increasing health and leisure. Given what we now know, much of this narrative is wrong or seriously misleading."

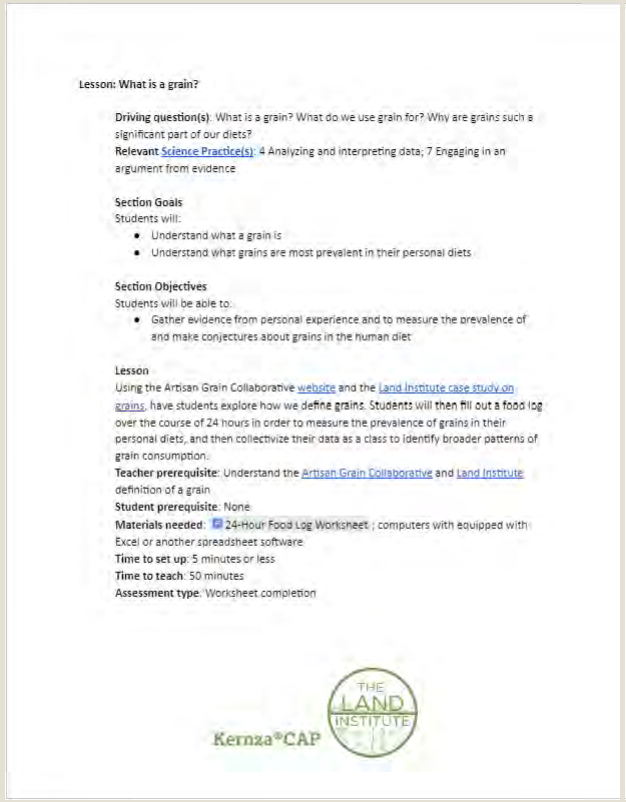
Pg 2.

"Anthropocene," was coined to name a new geological epoch during which the activities of humans became decisive in affecting the world's ecosystems and atmosphere.

Pg 3. Fire as the first domesticated thing/ tool for domestication

Pg. 6-8

Using Lessons for Younger Audiences



Lesson: What is a grain?

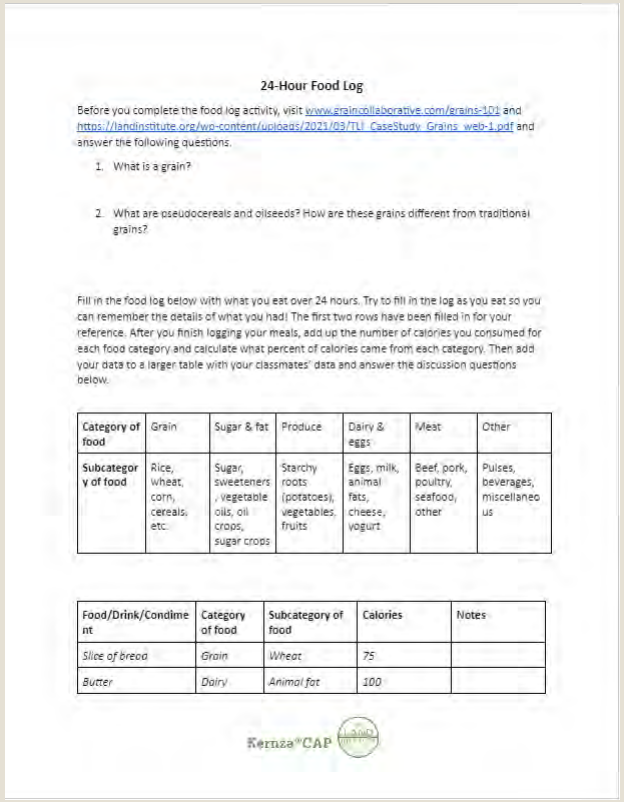
Driving question(s): What is a grain? What do we use grain for? Why are grains such a significant part of our diets?
Relevant Science Practice(s): 4 Analyzing and interpreting data; 7 Engaging in an argument from evidence

Section Goals
Students will:
- Understand what a grain is
- Understand what grains are most prevalent in their personal diets

Section Objectives
Students will be able to:
- Gather evidence from personal experience and to measure the prevalence of and make conjectures about grains in the human diet

Lesson
Using the Artisan Grain Collaborative website and the Land Institute case study on grains, have students explore how we define grains. Students will then fill out a food log over the course of 24 hours in order to measure the prevalence of grains in their personal diets, and then collectivize their data as a class to identify broader patterns of grain consumption.
Teacher prerequisite: Understand the Artisan Grain Collaborative and Land Institute definition of a grain
Student prerequisite: None
Materials needed: 24-Hour Food Log Worksheet ; computers with equipped with Excel or another spreadsheet software
Time to set up: 5 minutes or less
Time to teach: 50 minutes
Assessment type: Worksheet completion

Kernza®CAP



24-Hour Food Log

Before you complete the food log activity, visit www.grainscollaborative.com/grains-101 and https://landinstitute.org/wp-content/uploads/2021/03/TLI_CaseStudy_Grains_web-1.pdf and answer the following questions.

1. What is a grain?

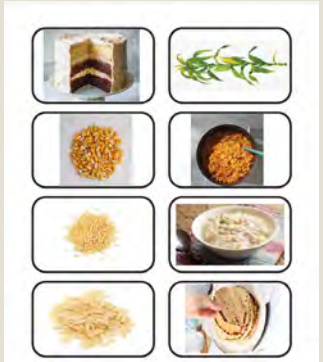
2. What are pseudocereals and oilseeds? How are these grains different from traditional grains?

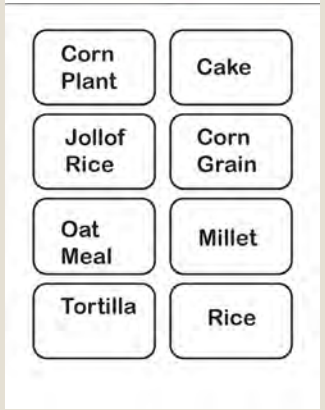
Fill in the food log below with what you eat over 24 hours. Try to fill in the log as you eat so you can remember the details of what you had! The first two rows have been filled in for your reference. After you finish logging your meals, add up the number of calories you consumed for each food category and calculate what percent of calories came from each category. Then add your data to a larger table with your classmates' data and answer the discussion questions below.

Category of food	Grain	Sugar & fat	Produce	Dairy & eggs	Meat	Other
Subcategory of food	Rice, wheat, corn, cereals, etc.	Sugar, sweeteners, vegetable oils, oil crops, sugar crops	Starchy roots (potatoes), vegetables, fruits	Eggs, milk, animal fats, cheese, yogurt	Beef, pork, poultry, seafood, other	Pulses, beverages, miscellaneous

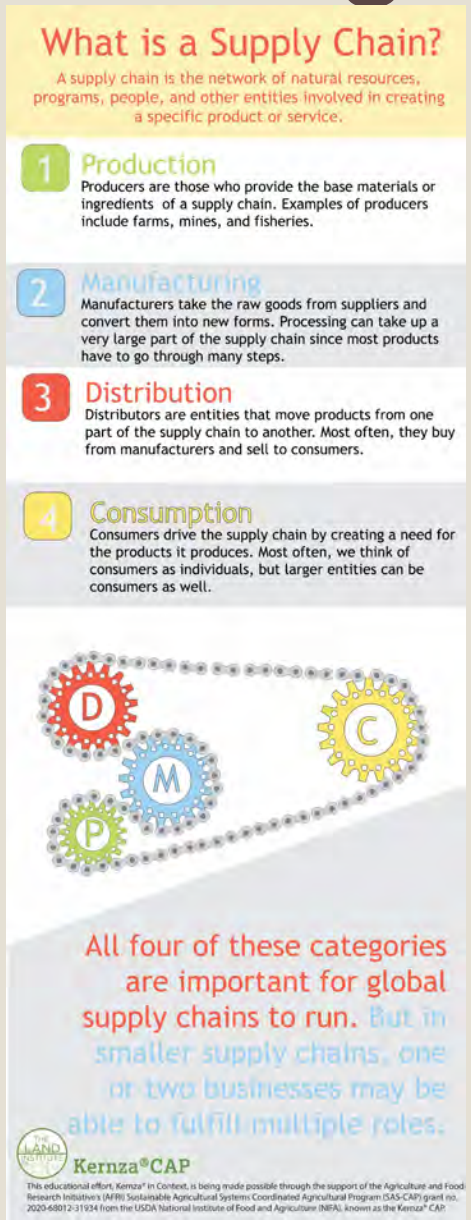
Food/Drink/Condiment	Category of food	Subcategory of food	Calories	Notes
Slice of bread	*Grain*	*Wheat*	*75*	
Butter	*Dairy*	*Animal fat*	*100*	

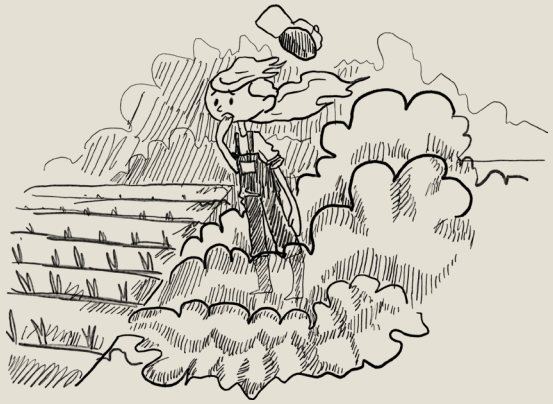
Kernza®CAP

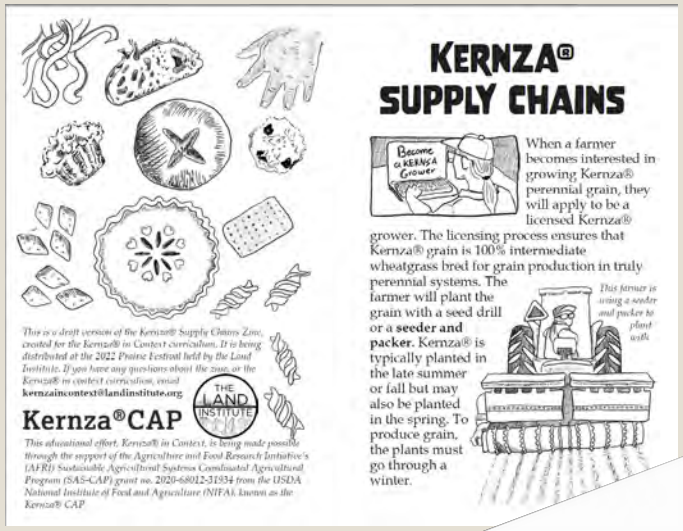




Using Materials from Lessons







The Keys to Kernza USDA Benefits

Dr. Cynthia Bartel

Kernza Con

June 22, 2023

Farm registration is critical:

- Program updates/deadlines
- Crop reporting & certification
- Ad-hoc programs

Program info.!

Timeline for application

NRCS CSP Perennial Grain Enhancement (E328O)

https://kernza.org/growers

2023 2024

JUNE
Begin conversations with your NRCS officer to receive approval

NOVEMBER*
Apply for Enhancement E328O

AUG / SEPT
Plant Kernza after enrollment

Begin now

Plant next year

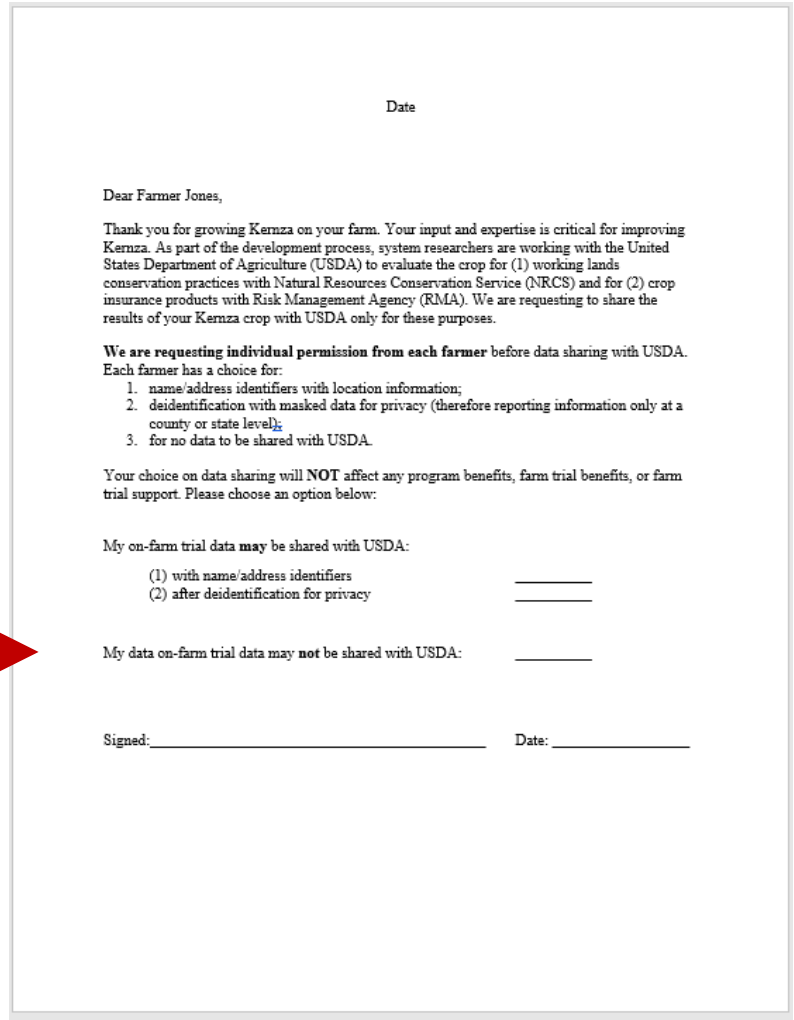
*Sign up deadlines are state-specific. November is the earliest deadline. Check with local NRCS for details.

USDA

Risk Management Agency

Focus on Framework:

- Farmer Consent Forms
- Data identification, collection, and infrastructure for crop insurance products



Date

Dear Farmer Jones,

Thank you for growing Kernza on your farm. Your input and expertise is critical for improving Kernza. As part of the development process, system researchers are working with the United States Department of Agriculture (USDA) to evaluate the crop for (1) working lands conservation practices with Natural Resources Conservation Service (NRCS) and for (2) crop insurance products with Risk Management Agency (RMA). We are requesting to share the results of your Kernza crop with USDA only for these purposes.

We are requesting individual permission from each farmer before data sharing with USDA. Each farmer has a choice for:

1. name/address identifiers with location information;
2. deidentification with masked data for privacy (therefore reporting information only at a county or state level);
3. for no data to be shared with USDA.

Your choice on data sharing will **NOT** affect any program benefits, farm trial benefits, or farm trial support. Please choose an option below:

My on-farm trial data **may** be shared with USDA:

(1) with name/address identifiers _____
(2) after deidentification for privacy _____

My data on-farm trial data may **not** be shared with USDA: _____

Signed:_____ Date: _____

Reflections/Key Factors:

- Equitable, scalable crop
- Excellent objective collaboration
- Technical policy analysis
- Funded by USDA for sanctioned work
- Leverage 20+ years scientific, policy and farming experience
    -> Relationships
- Call USDA service centers as farmer constituent
- No advocacy/lobbying activities
- Do not request specific outcome

Kernza®CAP

Minnesota Policy Advances

Supporting Research, Growers, and Entrepreneurs

Sienna Nesser
CLC Adoption Specialist, Forever Green Initiative

Mitch Hunter, PhD
Associate Director, Forever Green Initiative

Developing Grower Support with MN Dept. of Ag

PROGRAM GOALS

1. Support early on-farm adoption of Forever Green crops
2. Protect water quality through increasing continuous living cover
3. Field-specific ecosystem benefit payments
4. Outcomes/results-based
5. Local (state) innovation in programming for potential adoption by other states, federal gov, other

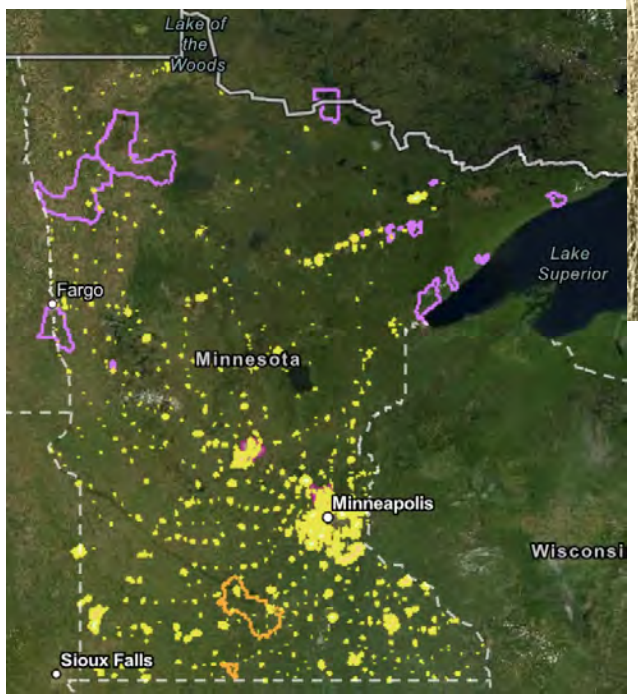


Photo credit: Erin Meier

EECO Program: Environmental and Economic Clusters of Opportunity

- Supporting early on-farm adoption of Forever Green crops
  - Kernza®
  - Winter camelina
  - Hybrid winter rye
  - Winter barley
- Funded by the MN Dept. of Agriculture
- Targets regions with impaired water quality

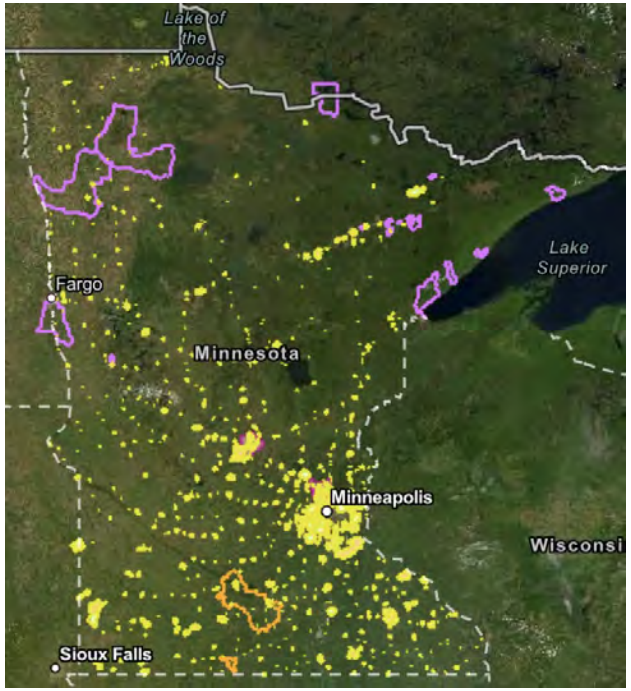



EECO Program: Environmental and Economic Clusters of Opportunity

- Grower-community-university Technical Assistance Team
- Two types of payments:
  - Ecosystem benefit ($25-50/ac Kernza, $20-40/ac winter annuals)
  - Economic risk - half the cost of production in the event of failure (think partial crop insurance without the premium)
- Seed and grain testing costs covered
- Goal of 5000 acres by 2024 across four crops

Forever Green EECO Implementation Program: Additional details

- 25% premium on ecosystem benefit payment if field is located within a DWSMA
- Kernza® growers must be licensed by The Land Institute



Forever Green Environmental and Economic Clusters of Opportunity (EECO) program

- $68,000 provided to growers
- 683 acres are included

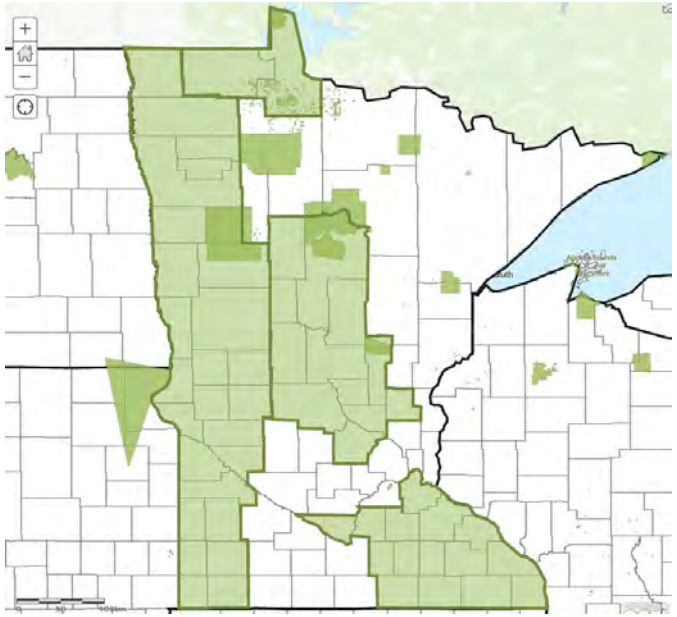


Photo credit: Erin Meier

Clean Water Fund

- $6M for 2024-2025
- Supports Forever Green Research Program
- Also EECO and the Forever Green Partnership

CLEAN WATER LAND & LEGACY AMENDMENT

Base Funding

- $802K per year, ongoing
- Long-term **stability**
- Top priorities:
  - Stabilize funding for breeders
  - Support management of Forever Green

Rep. Ginny Klevorn

Value Chain Grants

- $500K in 2023, another $500K in 2024-2025
- Grants to help **private businesses** and other organizations take Forever Green crops from the lab to the marketplace
- Administered by MN Department of Agriculture
- Focused on:
  - Kernza® perennial grain
  - Hazelnuts
  - Winter camelina
  - Elderberry

Value Chain Outcomes

- Root these industries in MN
- Break through bottlenecks
- Accelerate growth
- Jobs in rural communities
- Build demand for Forever Green crops

Perennial Promise Grower's Cooperative


kaaltv.com

Forever Green Initiative

FRIENDS OF THE MISSISSIPPI RIVER

Minnesota Environmental Partnership

Kernza® Stewards Alliance

Tessa Peters, Director of Crop Stewardship

THE LAND INSTITUTE

Purpose

Creating the Kernza Steward Alliance centers stakeholders in decision making and establishes a strategy & plan for long-term success.

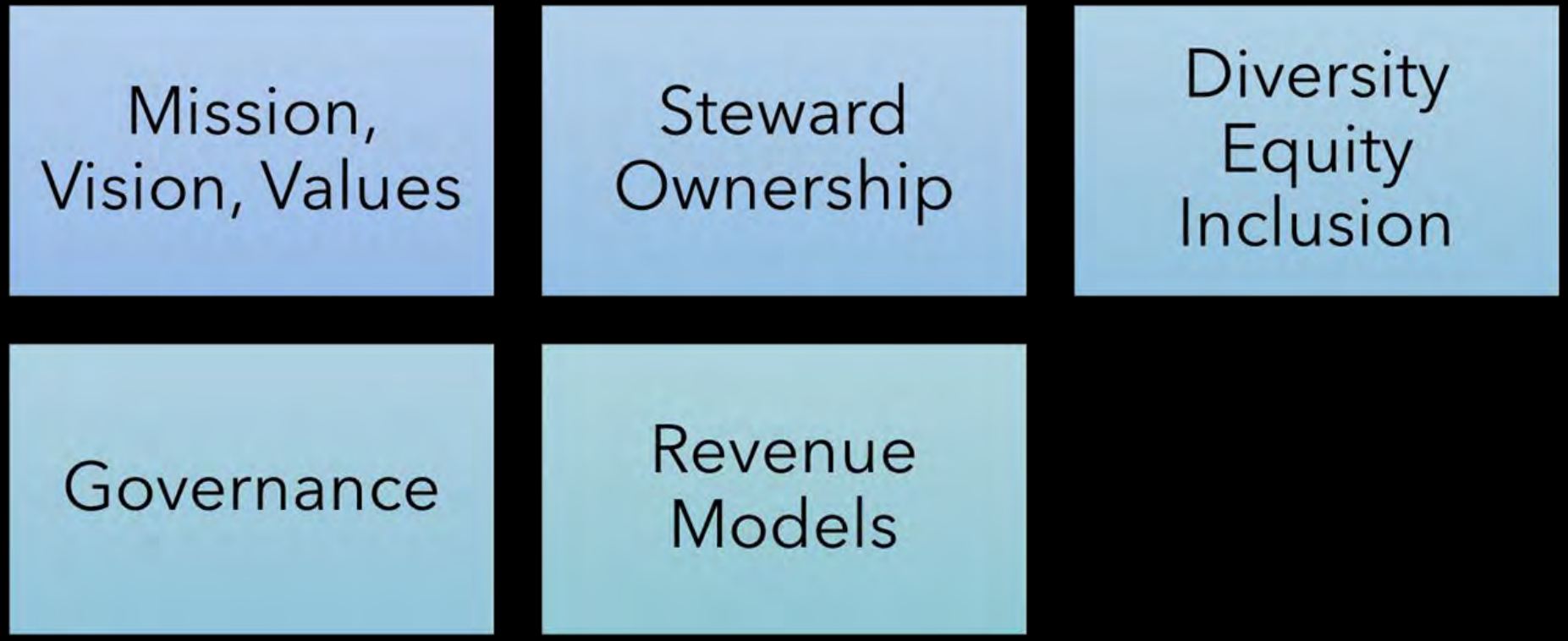
Power - Those bearing greatest risks (growers + businesses) should have a say in decision-making

Voice - Kernza's governance model should allow a voice for licensees + non-licensees

Protection - We need to collectively protect Kernza's 'purpose' + vision

Growth - We need to allow for nimble market activity

What we have done



Mission: Guiding and growing Kernza's future, together.

Vison: Vibrant ecosystems, vital economies, and healthy people through perennial grains.

Perpetual Purpose: Scale Kernza perennial grain, ensure stewards benefit from Kernza, and steward resources responsibly.

Innovation
Good ideas–guided by inspiration, purpose, study, and experience–grow into transformative results.

Equity
We embody fairness and, justice by uplifting diverse and underrepresented, stakeholders who support, Kernza.

Effectiveness
We are capable of advancing shared agendas, acting together, and making sound decisions.

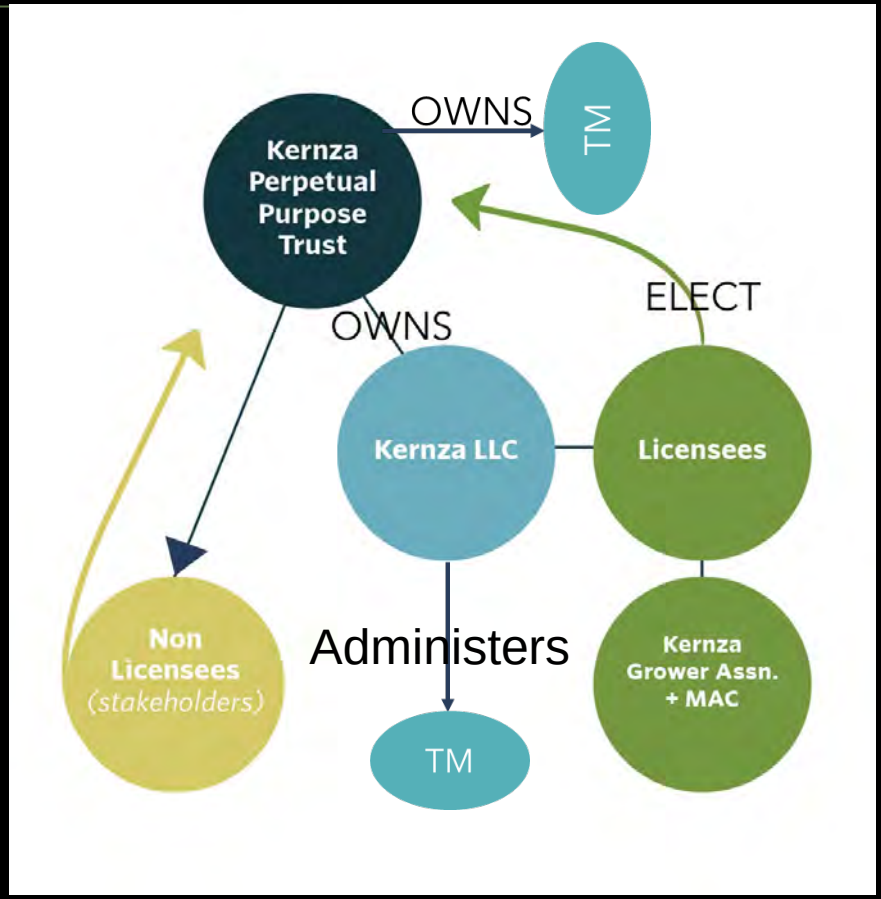
Urgency
We advance solutions at a pace and scale that mitigate the impact of our global climate crisis.

Collaboration
We foster cooperation through transparency, accountability, balance, and mutual respect.

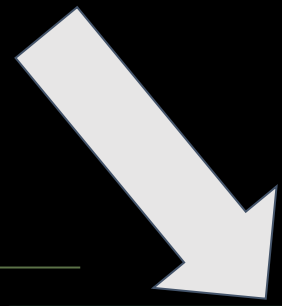
Longevity
We are Kernza stewards who generate lasting, shared value for our communities, ecosystems, and each other

Structure

Perpetual Purpose Trust Establishment



What's next?



Governance + Decision-Making	Formation of Legal Entities	IP + Supply Chain Management	Communication + Marketing
• Licensee v. non-licensee involvement • On-ramps for new members • Intentional inclusion practices	• Document filing • Transitioning TM ownership • Board selection	• Address supply/demand dynamics • IP compliance & audit support • Determine grain valuation for ecosystems	• Interface with other partners • Clear and direct communication among licensees • Marketing & promotion

Real talk - Why have we paused

- **Funding from CAP can’t be used on lawyers**
- **The Kernza market has been very slow and investing in legal structures feels premature**
  - We can invest in marketing endeavors instead

Moving to full commercialization

Thanks

If your life's work can be completed in your lifetime, you're not thinking big enough.

~ Wes Jackson

Research Update: Social Sustainability of Kernza®

Lightning talk:
Kernza Conference
June 2023

Amy Teller, PhD
Tara Conway, PhD Candidate
University of Minnesota
asteller@umn.edu & conwa304@umn.edu

Funding: Foundation for Food and Agriculture Research (FFAR) grant (PI, Nick Jordan, UMN)

Photo by Amy Teller at The Land Institute

Why social sustainability?

Intentions for Kernza to have social benefits, change systems, scale responsibly, and be part of a just perennial transition. Yet…

- Social sustainability is **not a given** alongside environmental sustainability during pilot stages or scaling.
- Harmful historical and present relationships are likely **reproduced** without early and ongoing evaluation and action.

Learning to care for a novel crop is an **opportunity to instigate** new relationships (Streit Krug & Tesdell 2021), which we can **make more visible and study**.

Just sustainability approach

Social sustainability & diversity/equity/inclusion/justice (DEIJ) are **not** the same thing, but they are connected.

1. To inform data collection, social sustainability is:
   the intersection point of what Kernza users want to see maintained [sustainability] and want to see change [justice] about their industries, supply chains, and communities

1. Collect data that **expands** the grounded stories we tell about how Kernza plays a part in people's varied responses to what they see as unsustainable conditions.

(Agyeman 2003; Valence et al. 2011; Hicks et al. 2016; Agyeman et al. 2016; Gaard 2017; Pellow 2018; Sze 2018; Hale et al. 2019; Ergas 2021)

What is social sustainability?

- We **don’t know yet** what social sustainability means in Kernza supply chains.

- The social is the least clearly defined and tracked aspect of sustainability in the literature and in practice (Valence et al. 2011; Hicks et al. 2016; Janker et al. 2019; Ergas 2021).

Contextual and co-creative process

Kernza presents an opportunity to define social sustainability and find ways to track it **contextually and in collaboration** with current/interested growers and supply chain businesses.

Research aims to strike the difficult middle ground between:

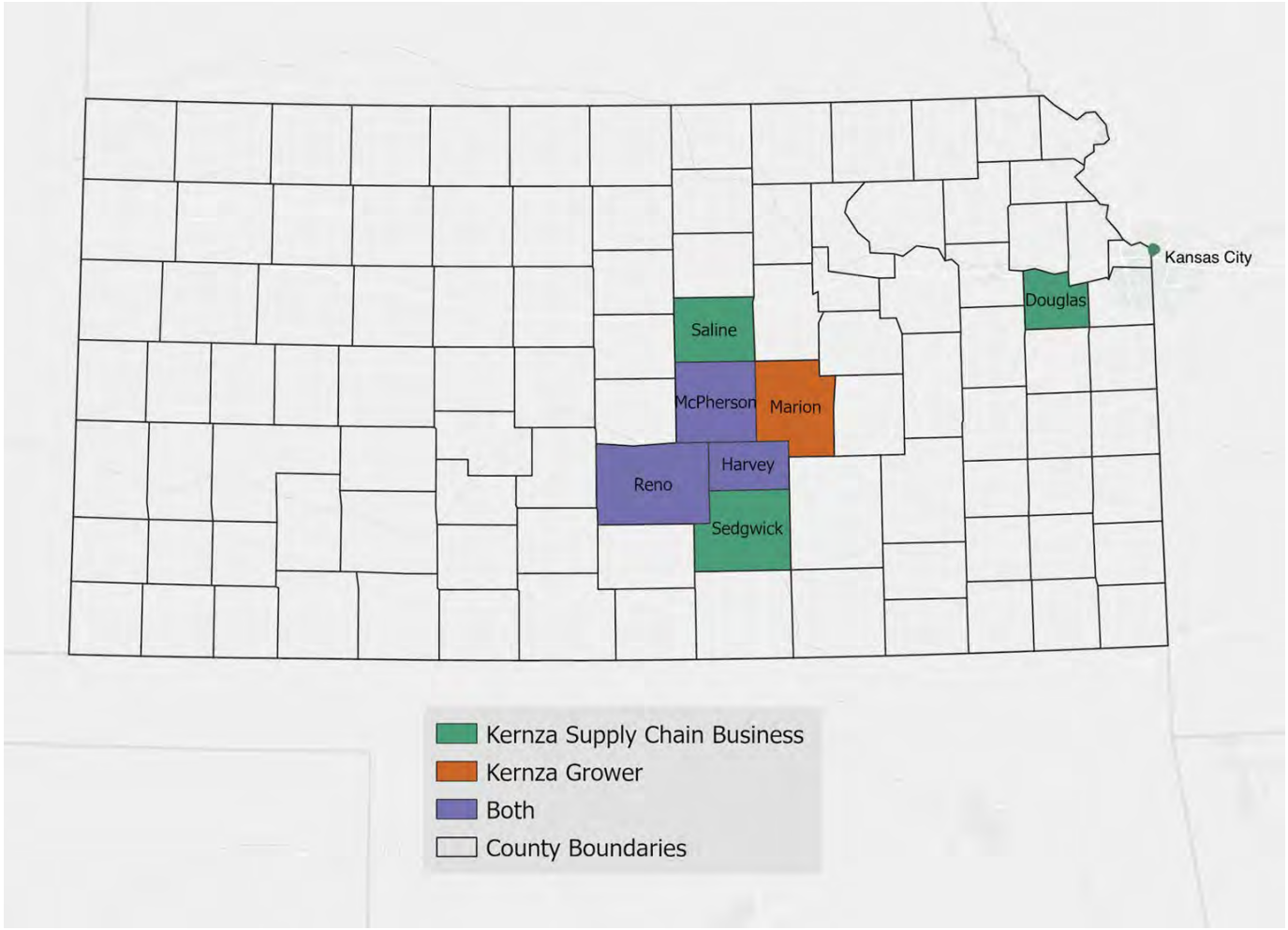
- Social sustainability left too vague
  - Allows business as usual
- One universal definition
  - Doesn't make sense in a specific context (i.e., perennial grain in MN/KS)
  - Risks leaving out important (historically/presently excluded) perspectives
- Both hinder accountability (Gaard 2017)

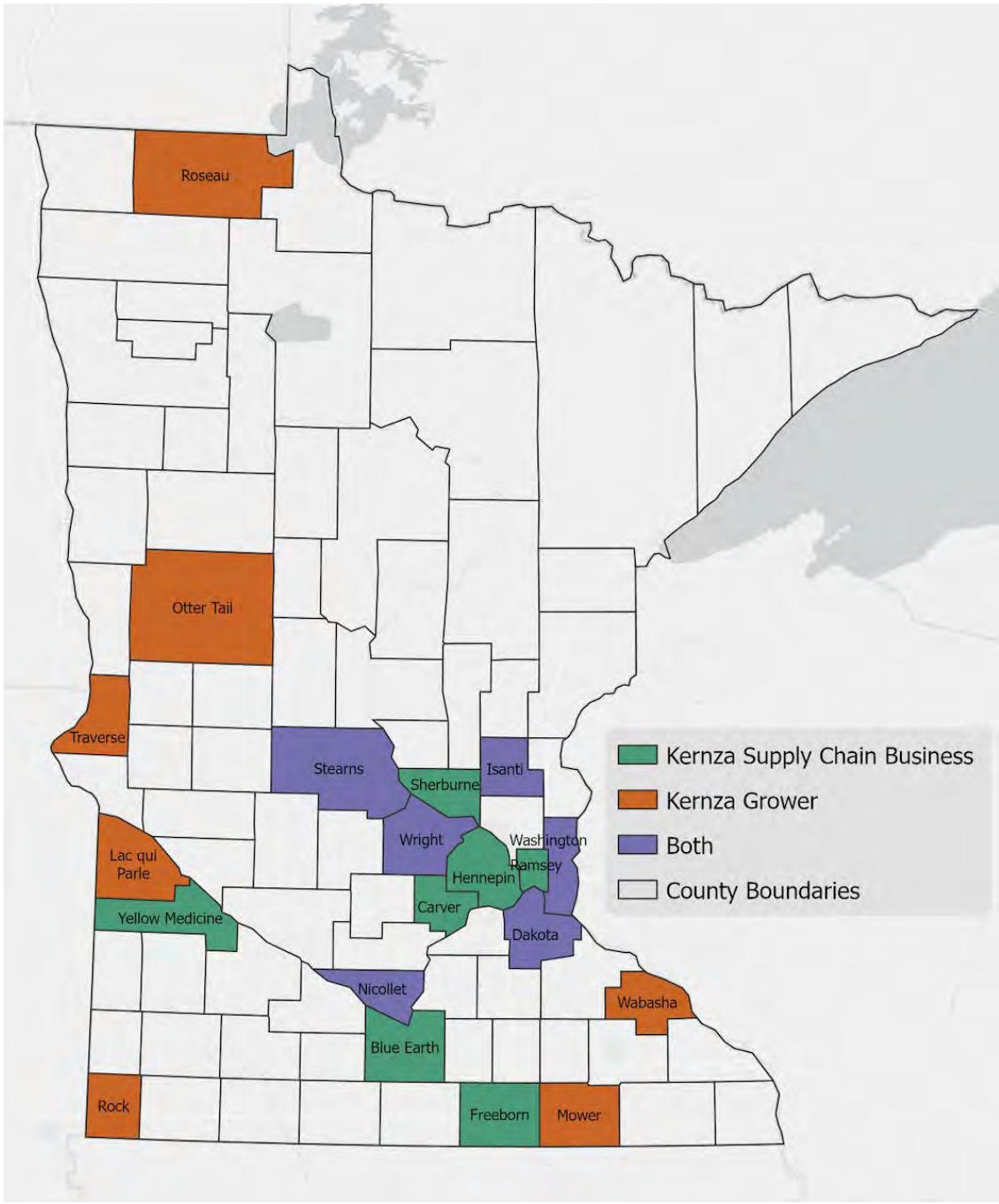
Photos by Amy Teller at Kimber Contours, MN and Lawrence Beer Co, KS

First phase of research (2022-2023): Supply chain interviews

Kernza supply chain actors	**Minnesota**	**Kansas**	**Total**
Growers	14 (of ~27)	6 (of ~9)	**20**
Rest of supply chain	30	10	**44**
Multinational/national companies	4		
Brewing-Distilling	12		
Culinary	7		
Baking	6		
Consumer packaged goods (CPGs)	4		
Processing/Seed/Milling	8		
Retail or Marketing	7		
Total N	**64**		

Counties in Kansas and Minnesota where interviewees are based





Phase 1: Supply chain interviews (completed in March 2023)	**Next phase** (Fall 2023 into 2024)

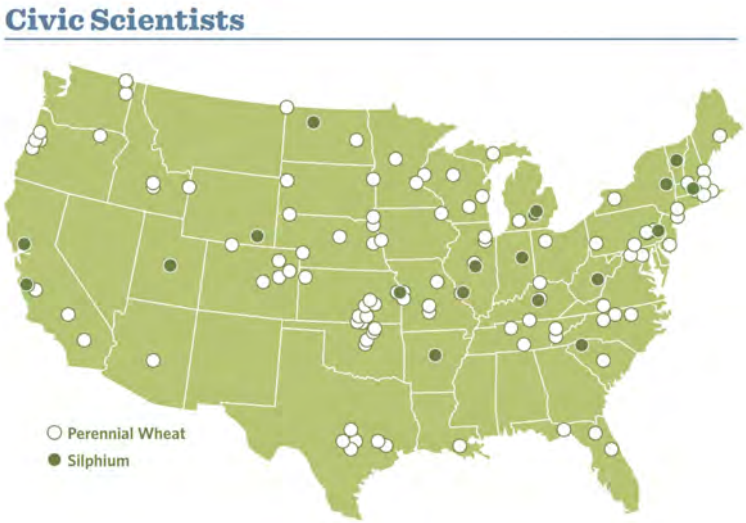
• Two types of data collected:
  ◦ Baseline evaluation using qualitative measures of social sustainability
  ◦ Meanings of social sustainability
 	
• Practical challenges and needs
 	
• Supply chain interviews as social sustainability practice
  ◦ Space to think and reflect; ask me questions and learn; notice reactions; receive input
	• Sharing initial findings at **July 25 KernzaCAP seminar** & in more ways coming soon (open to suggestions…)
	
	• Bring results to help with…
	  ◦ deciding how to collect and use social data for Kernza going forward
	  ◦ building mechanisms of accountability for responsible scaling into FGP, TLI & network

Tracing social sustainability through multiple sites of perennial transition…

Pilot perennial grain supply chains (Amy Teller)

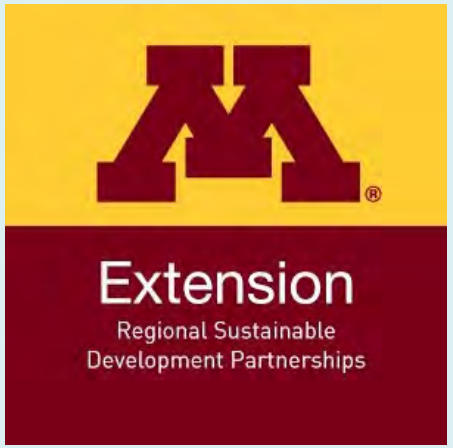
Intermediaries: Link between R&D institutions/NGOs <–> supply chain (Tara Conway)

Civic science program at The Land Institute (Aubrey Streit Krug)



Social Sustainability in Supply Chain and Policy Development

Forever Green's Learning and Experimentation Network (LEN)



Intermediaries

Individuals (or organizations) that make connections, build collaborations, and mobilize resources to create momentum for systemic change

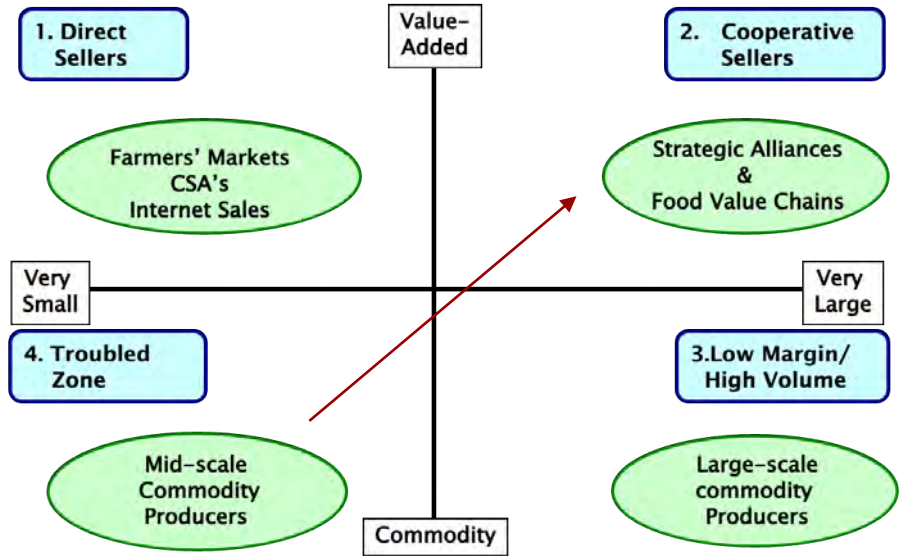
- Concerned with scaling and building new systems
- Concept comes from transitions to renewable energy systems in Europe
- In the case of Kernza, this work can look like:
  - Integrating crop research with the development of supply chains, demand, policy, financing
  - Synthesizing and sharing knowledge
  - Devising support programs like EECO

Kivimaa et al., 2019

Illuminating practice

- Questions:
  - What does this work look like?
  - Who is doing it? Who are they doing the work with and/or for?
  - Where?
  - Why do they their work?
  - Does this look different for different crops?
- Objective:
  - Make visible the labor undertaken by Kernza and Forever Green crop intermediaries
  - Illuminate network of relationships being built and maintained
  - Compare practices and strategies across cropping systems
    - How are environmental, social and economic aspects of sustainability litigated?

Strategic Business & Marketing Options



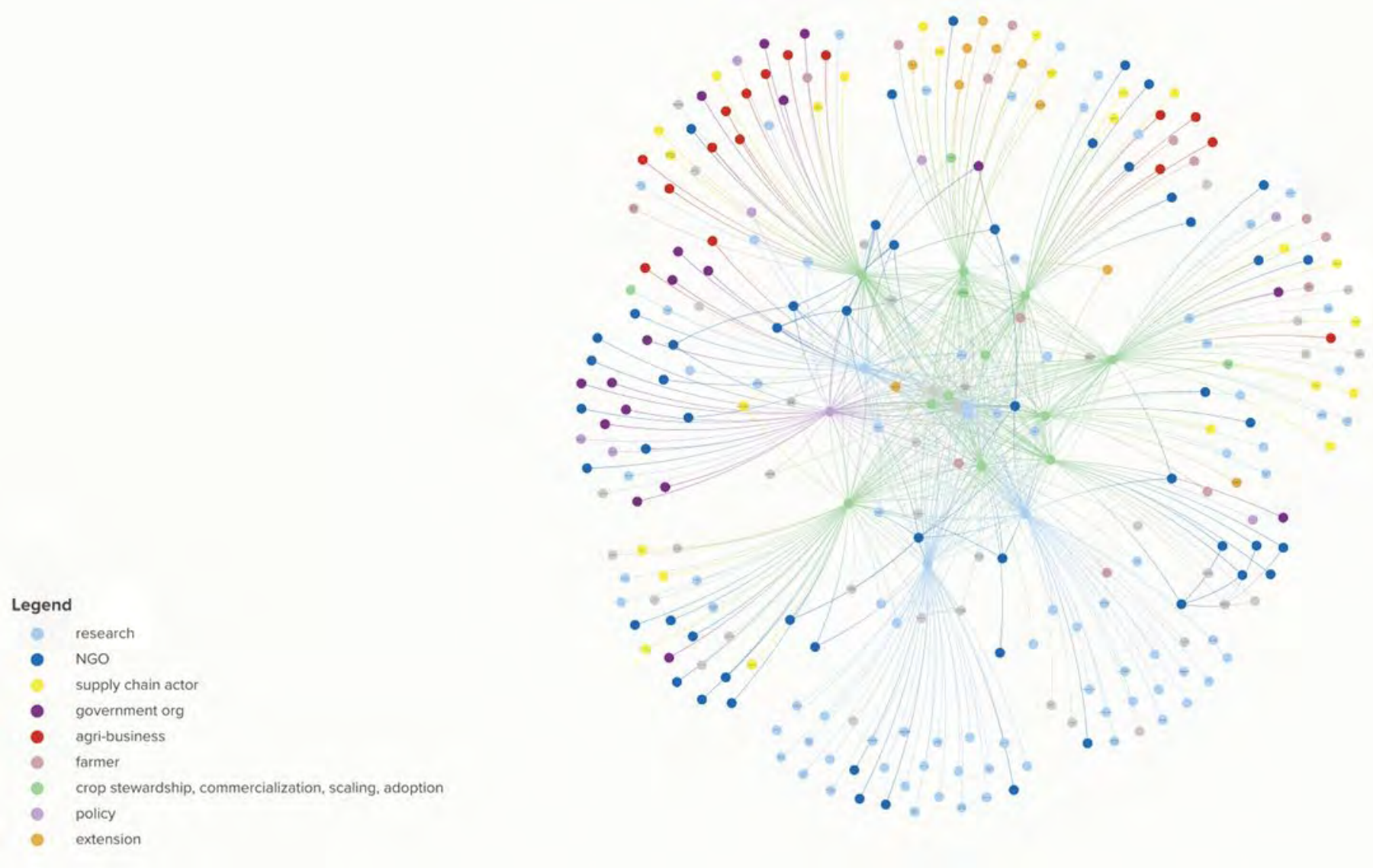
Source: Stevenson, GW. et al. 2011

Methods

- Interviews
  - Why do they do their work?
- Monthly work calendar time logs
  - What does this work look like?
  - Who are LEN members working with and/or for?
  - Where is this work happening?
- Group meeting facilitation
  - Space for collective reflection and mutual support

Work Activity	Length (hours)	Recurrence (in time period of four weeks)	Total time (hours)	Type of intermediary activity	Secondary intermediary activity (if applicable)	Crop (if applicable)	With who? (does not need to be individual names, c as 'Forever Green Researchers' or 'Kernza Commer
Forever green meetings	1	4	4	Learning		all	Forever green researchers, graduate students
IonE agriculture and climate coh	1.5	2	3	Facilitating		not CLC	UMN ag/climate graduate students
Institutional analysis class	1.5	4	6	Learning		not CLC	Forestry and natural resources PhD students interes
FGP DE meeting	1.5	2	3	Creating institutic	Framing and coordir	all	Nick, Kate, Keith
Care work meeting	1	1	1	Knowledge aggr		all	Aubrey, Amy
Coworker meeting	1.5	n/a	1.5	Facilitating	Knowledge aggrega	all	Sophia
Advisor meeting	0.5	4	2	Creating institutic		all	Nick
Writing block	4	2	8	Knowledge aggr		all	
RFP review	3	1	3	Brokering		not CLC	
Comparative indigenous methoc	2	4	8	Learning		not CLC	UMN graduate students interested in indigenous kn
LEN	1.5	1	1.5	Facilitating	Creating institutiona	all	LEN
Grad leaders meeting	1.5	2	3	Facilitating		not CLC	IonE graduate leaders cohort
IonE coworker meeitng	0.75	1	0.75	Framing and coo		not CLC	Terin (Humphrey PhD)
FEASt	1	2	2	Facilitating		not CLC	UMN graduate students interested in agroecology
FFAR research braiding	1	2	2	Knowledge aggr	Framing and coordir	all	Nick, Amy, Ian (prosocial)
FGP Steering Council	2	1	2	Facilitating		all	FGP SC
LEN member meeting	0.75	n/a	0.75	Facilitating		all	Sarah Lloyd
Kernza happy hour	2	n/a	2	Initiating and dea		Kernza	FGP-FGI kernza community
APG seminar committee	1.5	n/a	1.5	Configuring		not CLC	Two agronomy and plant genetics professors, two A

One month of LEN working relationships



- 695 connections
- 282 unique elements (either individuals or institutions)

The “juice” of our work

I'm drawn strongly to collective efforts to achieve something together… and so a lot of the sort of emotional juice in the work around scaling [crops like Kernza] comes from this sense that there are all these people that I think are lovely, admirable, interesting people trying to do something really, really hard… so I guess I’m motivated by a sense of kinship

-LEN member

Q&A

Thanks to our co-hosts & organizers!

Kernza®CAP

Forever Green

Green Lands Blue Waters

Thanks to our welcome reception sponsor!

TATTERSALL