

The Forever Green Agricultural Initiative S.F. 3711



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Forever Green Agriculture Initiative

Develop **Winter Annual and Perennial Crops** for inclusion in existing cropping systems that will provide a **Continuous Living Cover and New Economic Opportunities** for farmers and rural communities, while protecting soil and water resources.



New Food/Feed/Fuel
Ingredients



New Economic
Opportunities

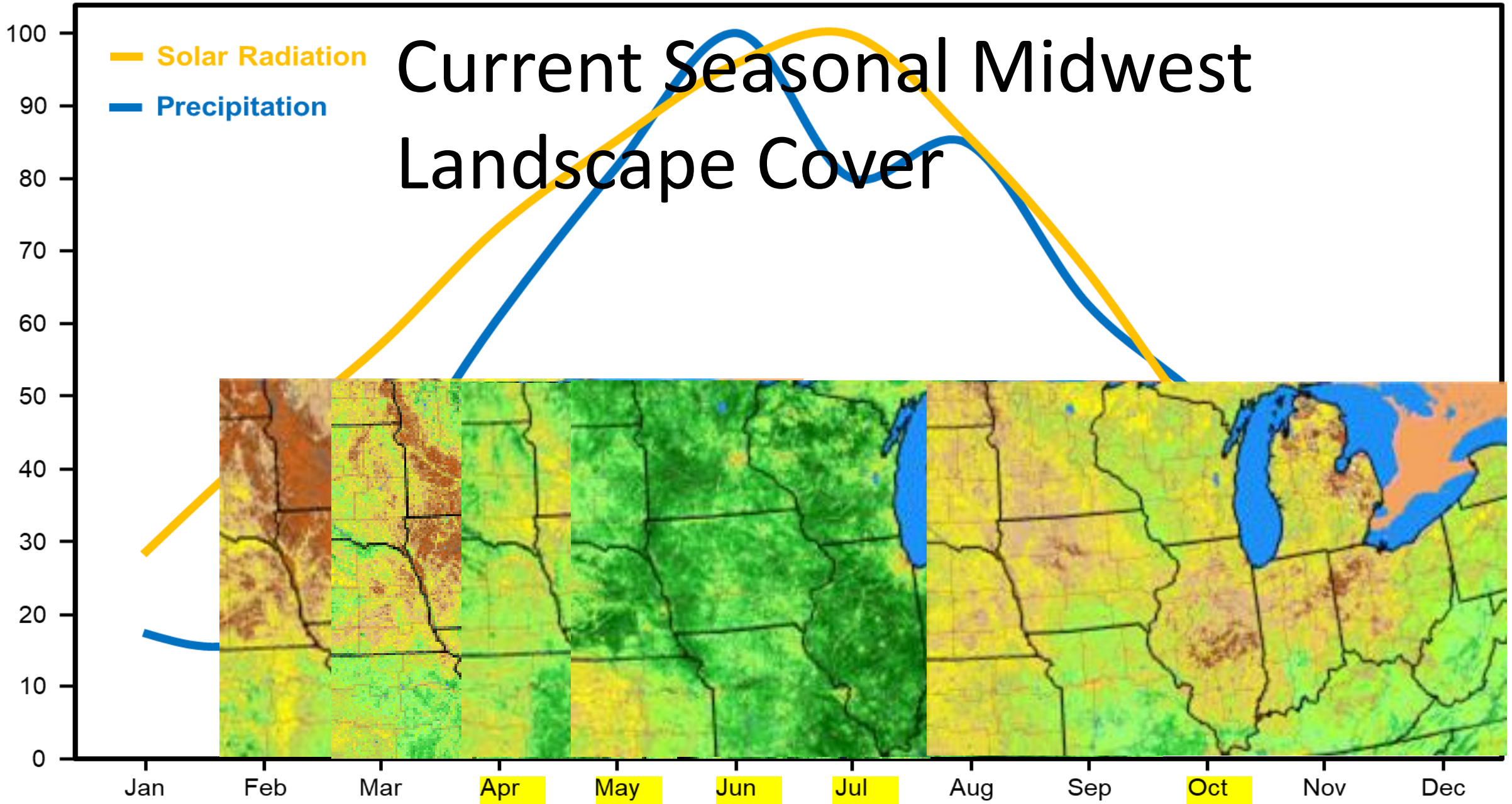


Ecosystem
Services

Percent of Maximum

Current Seasonal Midwest Landscape Cover

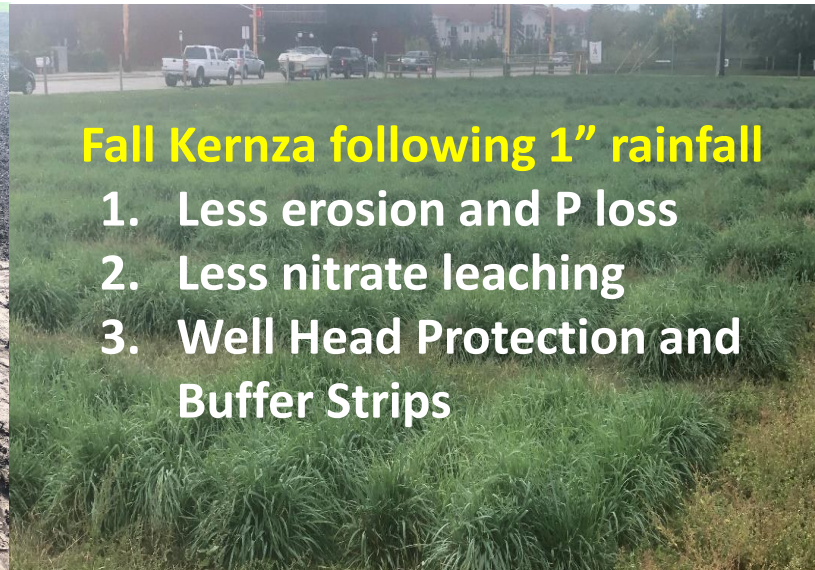
Solar Radiation
Precipitation



Continuous Living Cover Cropping Systems



Fall tilled field following 1" rainfall

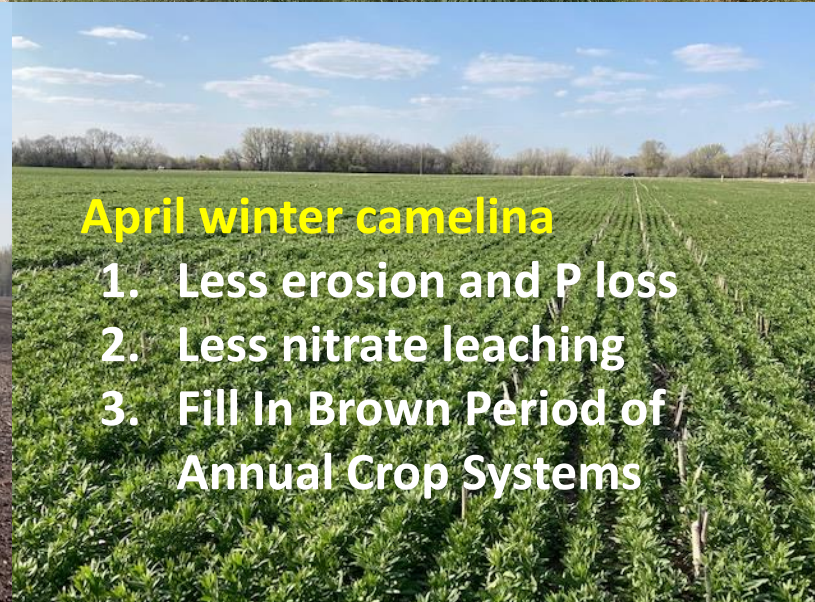


Fall Kernza following 1" rainfall

1. Less erosion and P loss
2. Less nitrate leaching
3. Well Head Protection and Buffer Strips



April field prep for summer annual crops



April winter camelina

1. Less erosion and P loss
2. Less nitrate leaching
3. Fill In Brown Period of Annual Crop Systems

Forever Green Crops Provide: New, Unique Food, Feed and Energy Products for Commercialization



Oils



Fiber



Protein



Phytonutrients

Forever Green Crops and Cropping Systems Provide: **New Economic Opportunities**



High Value Food, Feed and Energy
Ingredients



Green Marketing: Ecosystem Services,
Green House Gas Reduction



Innovative Healthy Food Products



New Economic Opportunities for
Farmers and Rural Communities

Forever Green Crops Provide: Environmental Services

- Rural well water protection
- Clean water
- Nutrient management
- Pollinator habitat
- Carbon sequestration
- Soil protection
- Soil Health



How do we get these plants on the landscape?

Collaboration across disciplines in both public and private sectors



Plant Breeding and Genomics



Agronomics



Food Science



Commercialization



Supply Chain Development



Perennial Crops

- **Intermediate wheatgrass “Kernza”** – grain, forage, biomass
- **Perennial sunflower** – edible seeds, oil & protein
- **Native polyculture grassland mixtures** – biomass, forage natural products
- **Perennial flax** – edible oil and protein
- **Kura clover** – N-fixing cover crop
- **Silphium** – edible oil and protein
- **Alfalfa** – food grade protein and feed
- **Perennial Cereal Rye** – food and feed grain

Winter Annual Crops

- **Pennycress** – edible oil & protein, biofuel
- **Camelina** – edible oil & protein, biofuel
- **Winter barley** – food, malting barley
- **Hairy vetch** – N-fixing cover crop
- **Winter and spring field pea** – food grade protein
- **Winter Hybrid rye**—food and feed grain

Native Woody Crops

- **Hazelnuts** – edible nut with oil/protein
- **Shrub willow** – biomass
- **Elderberry** – antioxidant-rich fruit
- **Agroforestry** – woody, herbaceous crop mixtures for feed, food, and fuel



Commercial Forever Green Food Products

PANCAKES WITH A PURPOSE

The latest delicious dish made with **KERNZA**® sustainable grain.



Birchwood CAFE

KERNZA® • Regenerates Topsoil • Draws Down Carbon



THE PERENNIAL



4 OZ
FLOUR FREE

SPROUTED whole grain KERNZA



patagonia PROVISIONS



ORGANIC KERNZA® FUSILLI
perennial grain pasta

NET WT. 14 OZ (397g)

USDA ORGANIC




LIMITED EDITION

CASCADIAN FARM ORGANIC

MADE WITH **CLIMATE SMART KERNZA GRAINS**

SOIL HEALTH WATER HEALTH



NET WT. 14 OZ (397g)

USDA ORGANIC



Perennial PANTRY™

Kernza® WHOLE GRAIN

RESEALABLE BAG

THE WORLD'S FIRST 100% WHOLE GRAIN

TEAR HERE

How Flavor-packed staple is in the pantry

perennial whole grain cereal
made with 100% kernza
whole grain flour and organic
cinnamon and fruit

HELP SAVE THE PLANET

NET WT 14 OZ (397g)



DUMPLIN & STIR-FRY NOODLERS AT LARGE

EXCEPTIONALLY CURIOUS NOODLES

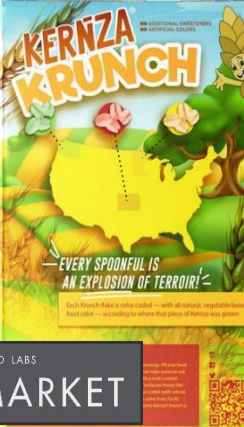


KERNZA KRUNCH

PERENNIAL WHEATGLASS CEREAL

THE ALPHA FOOD LABS

FUTURE MARKET



KERNZA KRUNCH

EVERY SPOONFUL IS AN EXPLOSION OF TERROIR!

Each spoonful is a whole grain — with all natural, vegetable-based food color — according to where that piece of future was grown.

THE ALPHA FOOD LABS

FUTURE MARKET

Forever Green Crops: From Research to Field to Table





Progress To Date, In-Part Supported by State of Minnesota Funding



Established New Partnerships and Platforms

- State funds leveraged 5-fold
- 16 coordinated Forever Green Crop development platforms
- Coordination of FGI with MN communities, seed companies, farmers, grain processors, and commercialization and supply chain network

Product Development

- 'MN-Clearwater' Kernza™ variety
- Winter Barley variety
- Winter hardy hairy vetch variety
- 6 hazelnut lines for on farm evaluation
- Short season winter camelina line
- Domesticated pennycress, a winter hardy oilseed crop

Overview of Three Forever Green Initiative Crops Being Developed

Perennial Crop

- Intermediate wheatgrass - Kernza



Winter Annual Crops

- Pennycress
- Camelina



Intermediate Wheatgrass or Kernza™

Thinopyrum intermedium

Perennial grass with high biomass and large grain size

Enterprises

- Beer/Whiskey
- Food
- Biomass
- Grazing





Annual wheat (on left in each panel) and Perennial wheatgrass

Intermediate Wheatgrass: Attributes



Large seeds

- 10-15g/1000 seeds



Grazing potential

- Fall and spring grazing
- High forage quality
- Grazing helps maintain grain yield



Large biomass

- Comparable to big bluestem and switchgrass

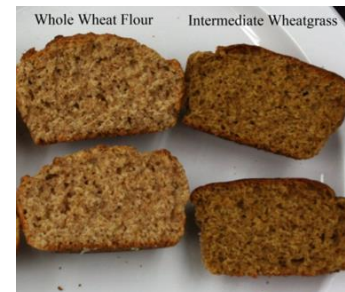


Production in Buffer and Well Head Protection Areas



Disease resistance

- Lr38, Sr43, Sr44, Pm40, Pm43...



Favorable end-use food

- Wheat-wheatgrass blends
- High protein
- Unique flavor

Intermediate Wheatgrass: Breeding Goals

- Grain Yield
- Yield Longevity
- Seed Size
- Shatter Resistance
- Free Threshing
- Spike traits (length, weight)
- Height
- Lodging Resistance
- Diseases (FHB, Ergot)
- End-use Quality & Food Products



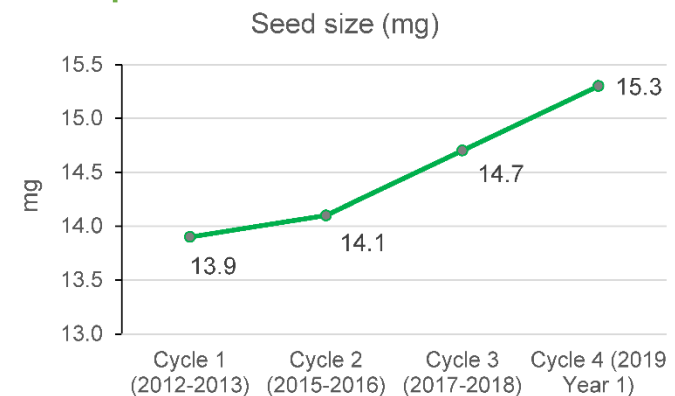
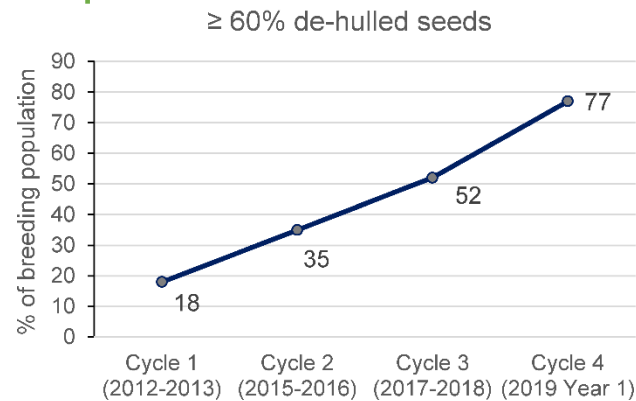
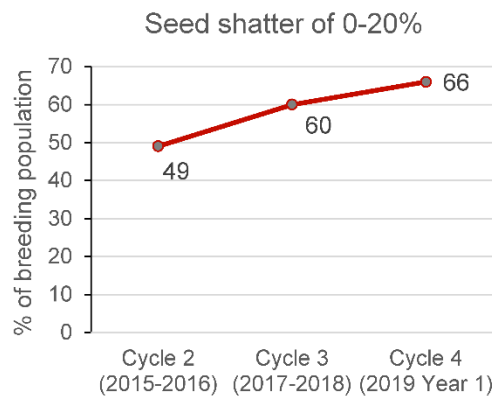
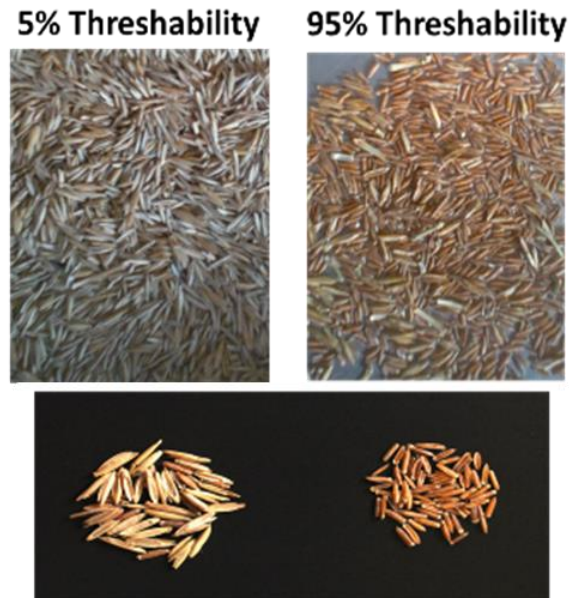
Dr. Pam Ismail



Dr. George Annor

Intermediate Wheatgrass: Genetic Selection

Trait Improvement after 4 Breeding Cycles

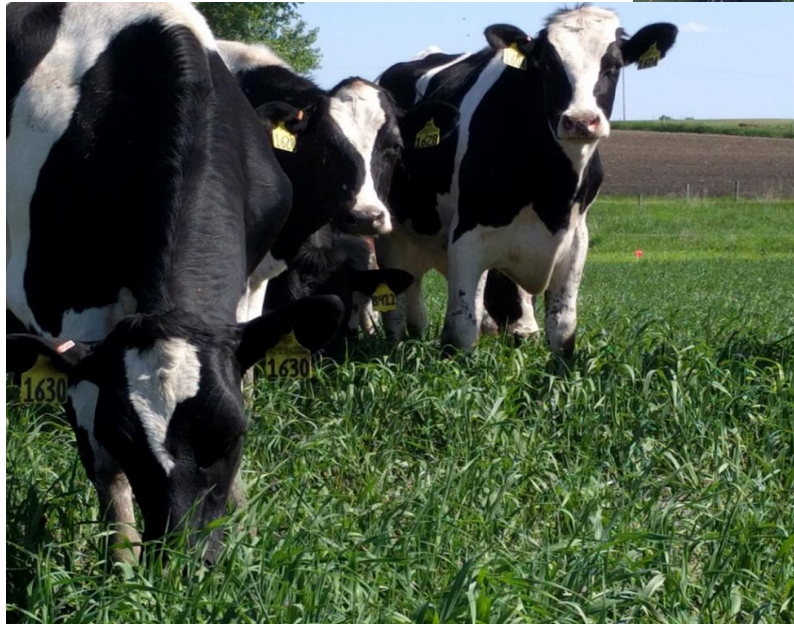


Release of 'MN-Clearwater'



Intermediate Wheatgrass: Agronomics

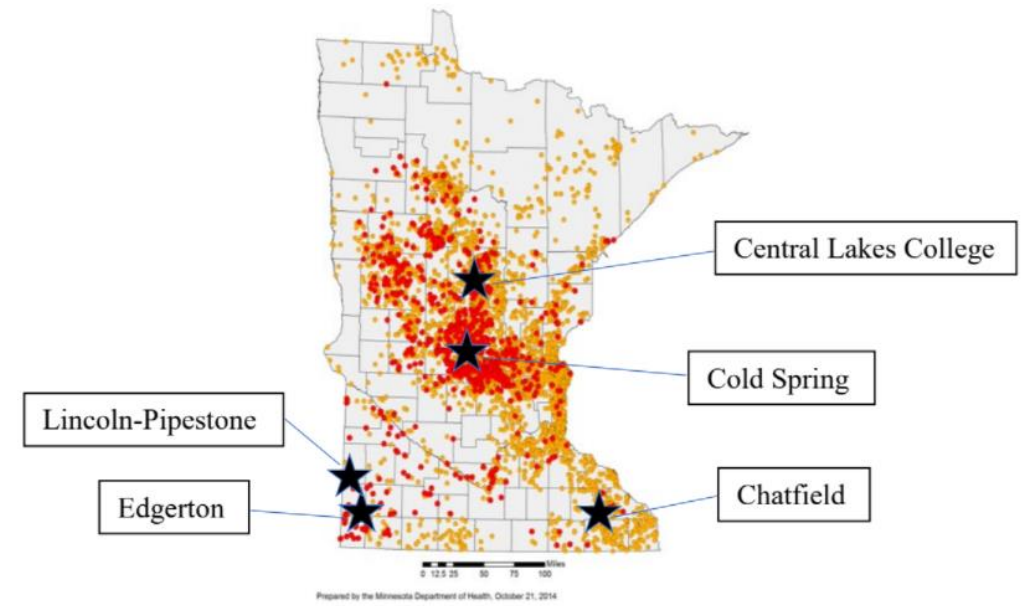
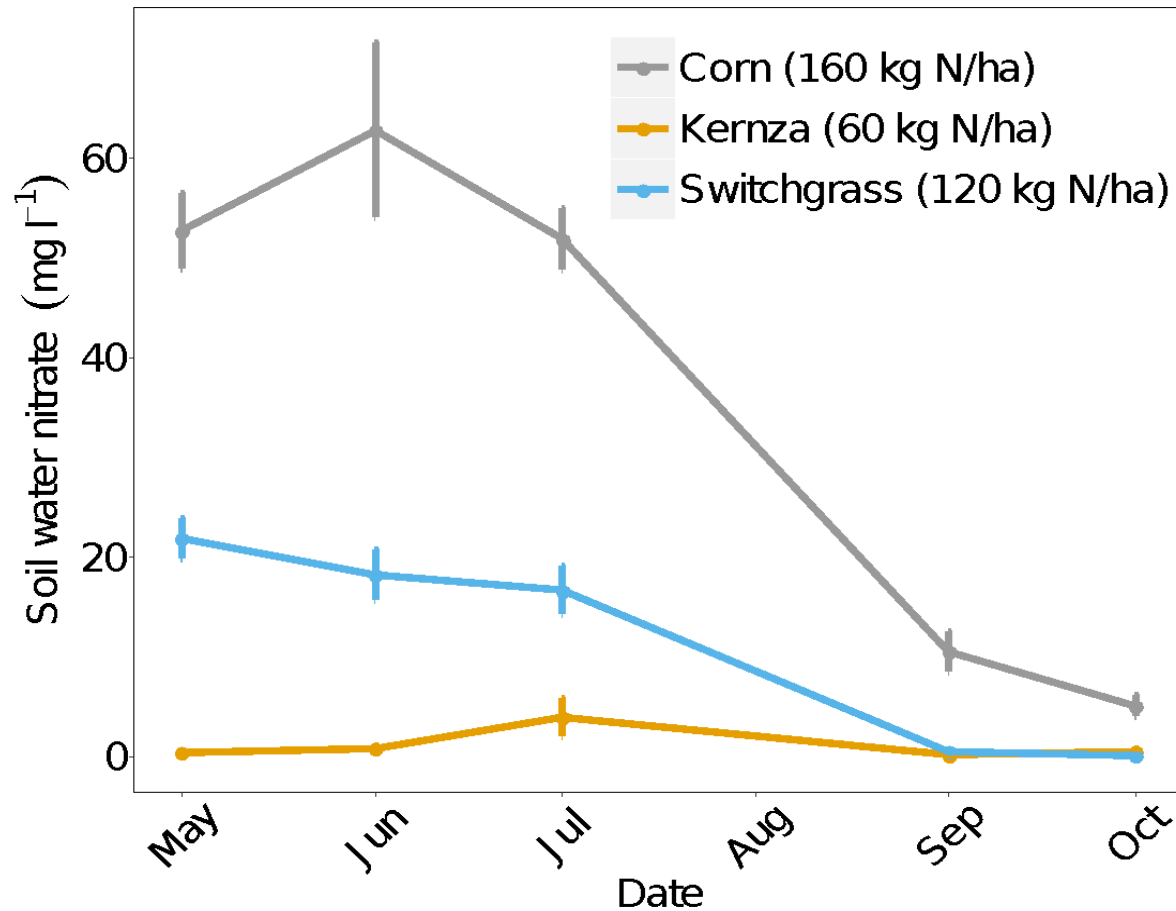
- Nitrogen rates
- Row spacing
- Harvest timing
- Grazing – dual use
- Legume intercropping
- Yield persistence



Intermediate Wheatgrass: Water Quality

Drastic reductions in nitrate leaching potential

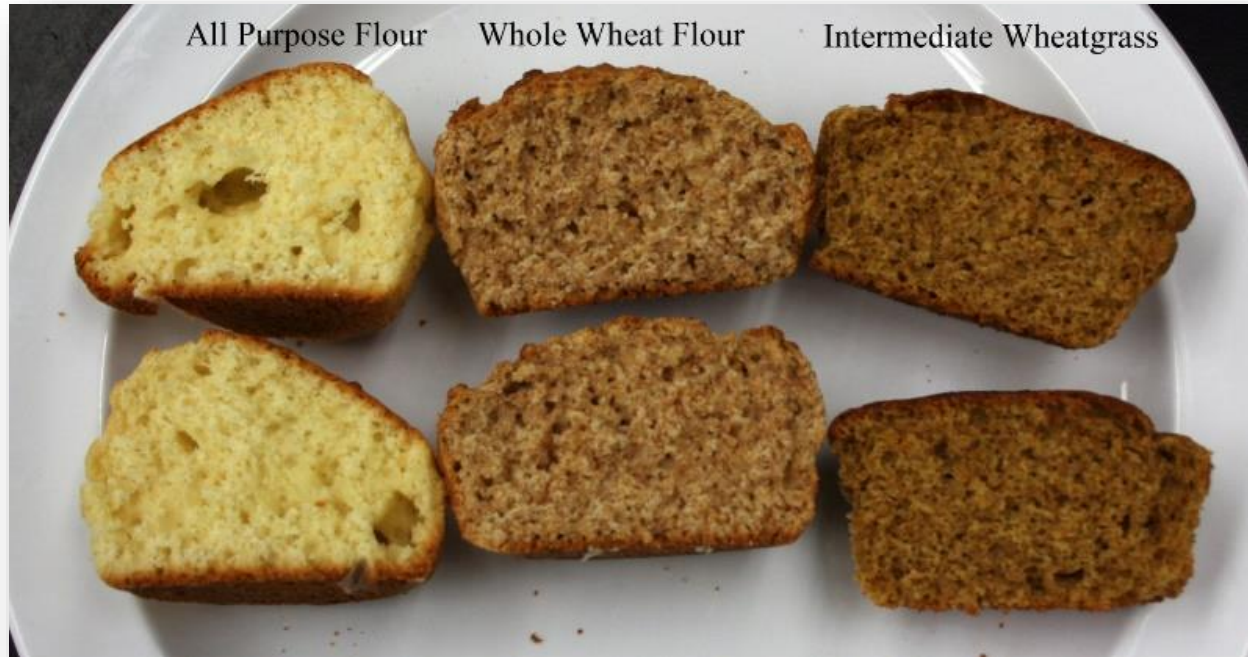
KERNZA
LONG ROOT



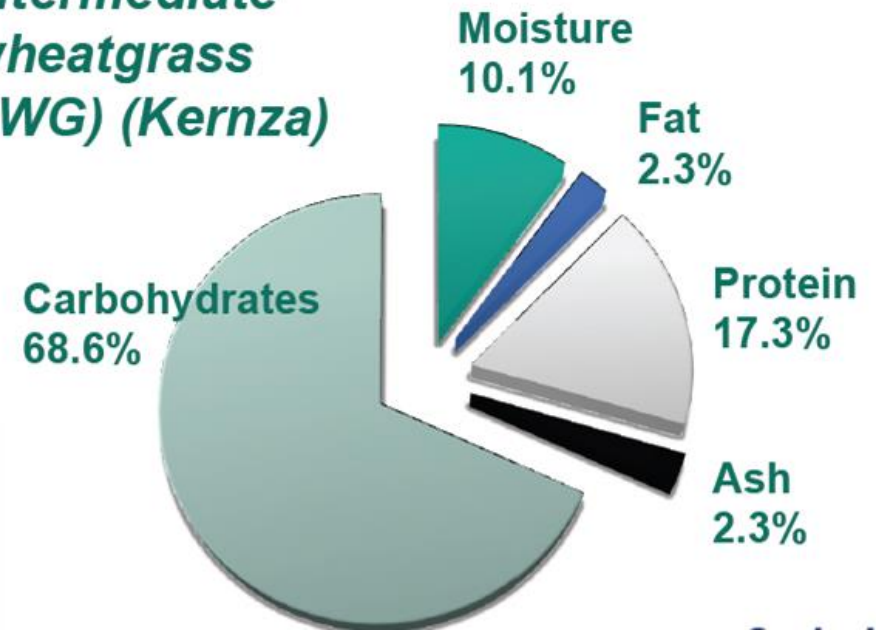
Private wells at risk of nitrate contamination in Minnesota.
Credit: Minnesota Department of Health.

Kernza: Food Science

- Gluten composition
- Protein analysis
- Storability
- Flavor profiling

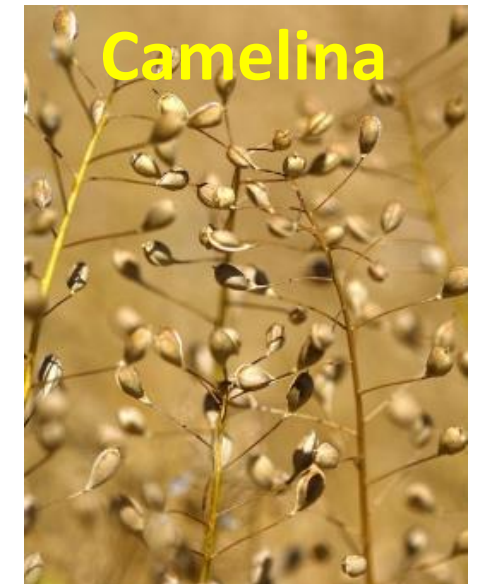
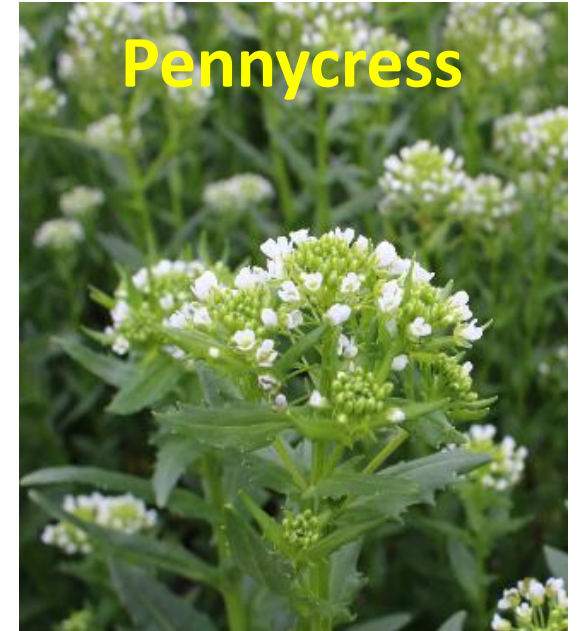


Intermediate wheatgrass (IWG) (Kernza)



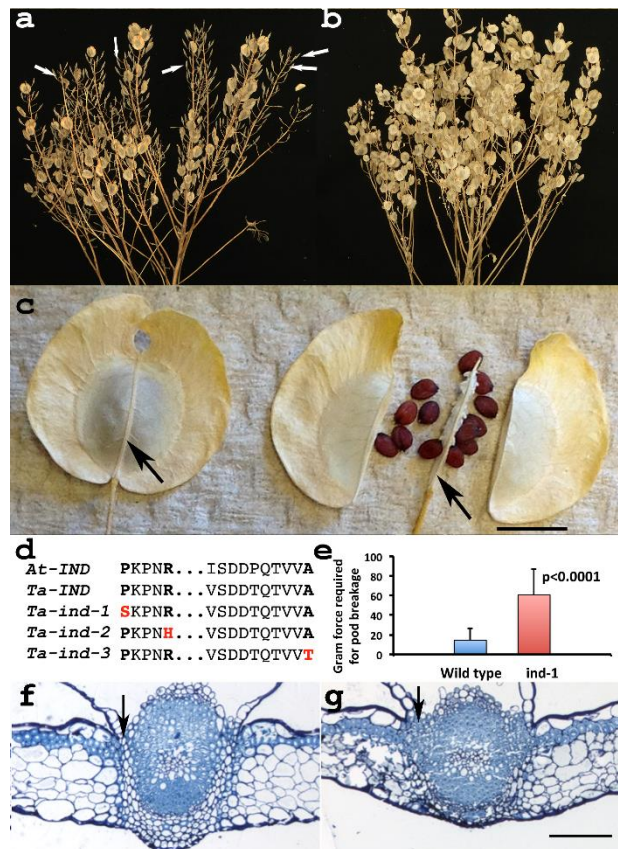
Pennycress and Camelina

- Mustard family
 - Produces an oilseed
 - Wild pennycress has a garlic smell and camelina a mustard-like smell
- Winter and spring annual forms
 - Winter annual is extremely freeze hardy
- High yielding, high oil content
- Food and Industrial uses
 - Pennycress: **industrial oil, not edible** - high erucic acid and glucosinolates
 - Camelina: **edible** - heart healthy oil



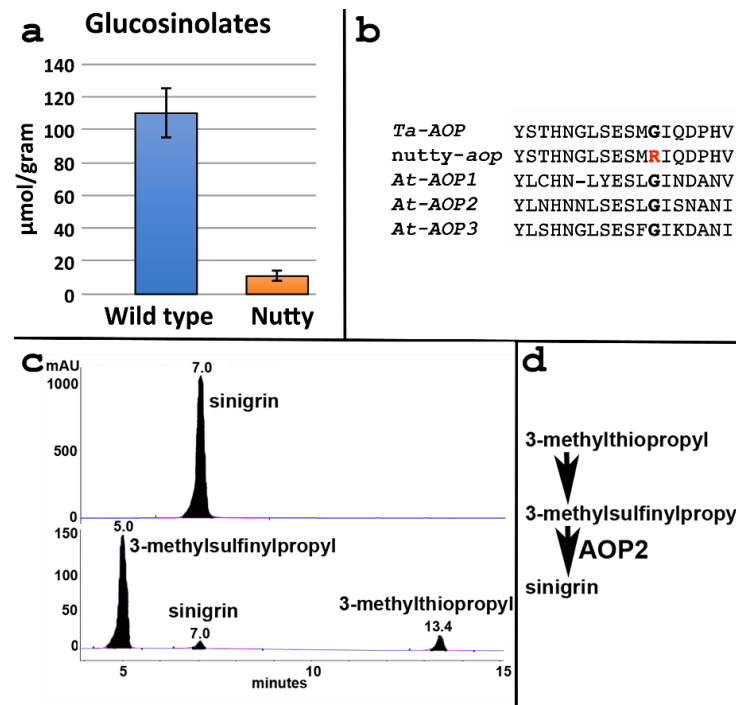
Domestication of Pennycress and Camelina as Food/Energy Crops

Reduced Seedpod Shatter



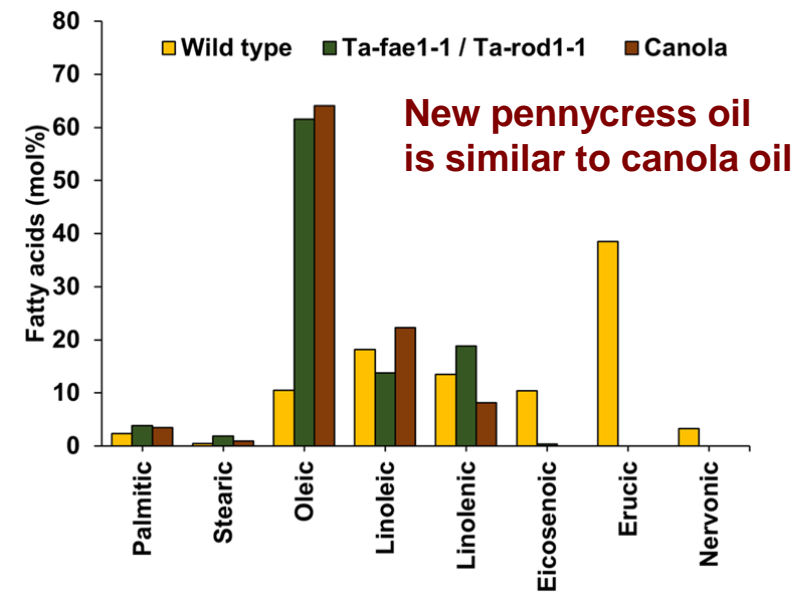
Improve yields by reducing loss due to seedpod shatter during harvest

Reduced Seed Anti-Nutritional Glucosinolates



Breeding programs are selecting for short season camelina and pennycress so the two crops can be incorporated into corn, soybean and wheat rotations to provide economically viable continuous living cover.

Reduced Erucic and PUFAs

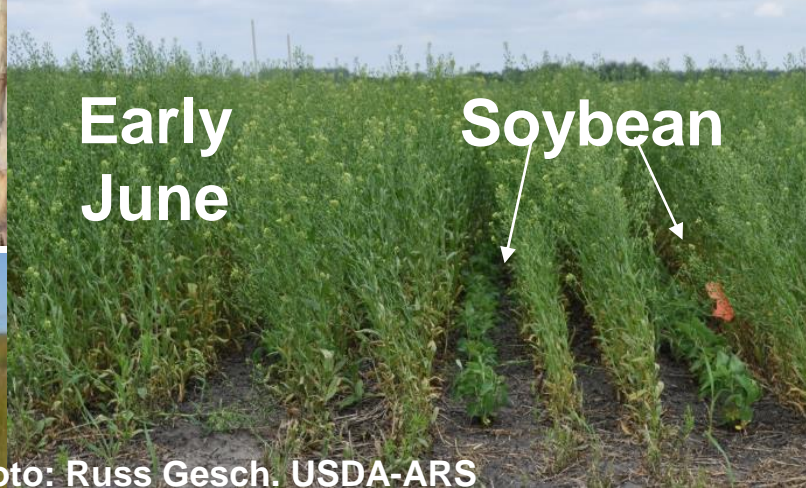


Research Objectives in Corn-Soybean System

- Develop BMPs for establishing pennycress and camelina in grain corn systems
- Evaluate ecosystem-benefits from integrating pennycress and camelina into corn-soybean systems



Oilseed Cropping System: Overview



Pennycress and Camelina as Cover Crops Reduce Nitrate Leaching into Ground Waters

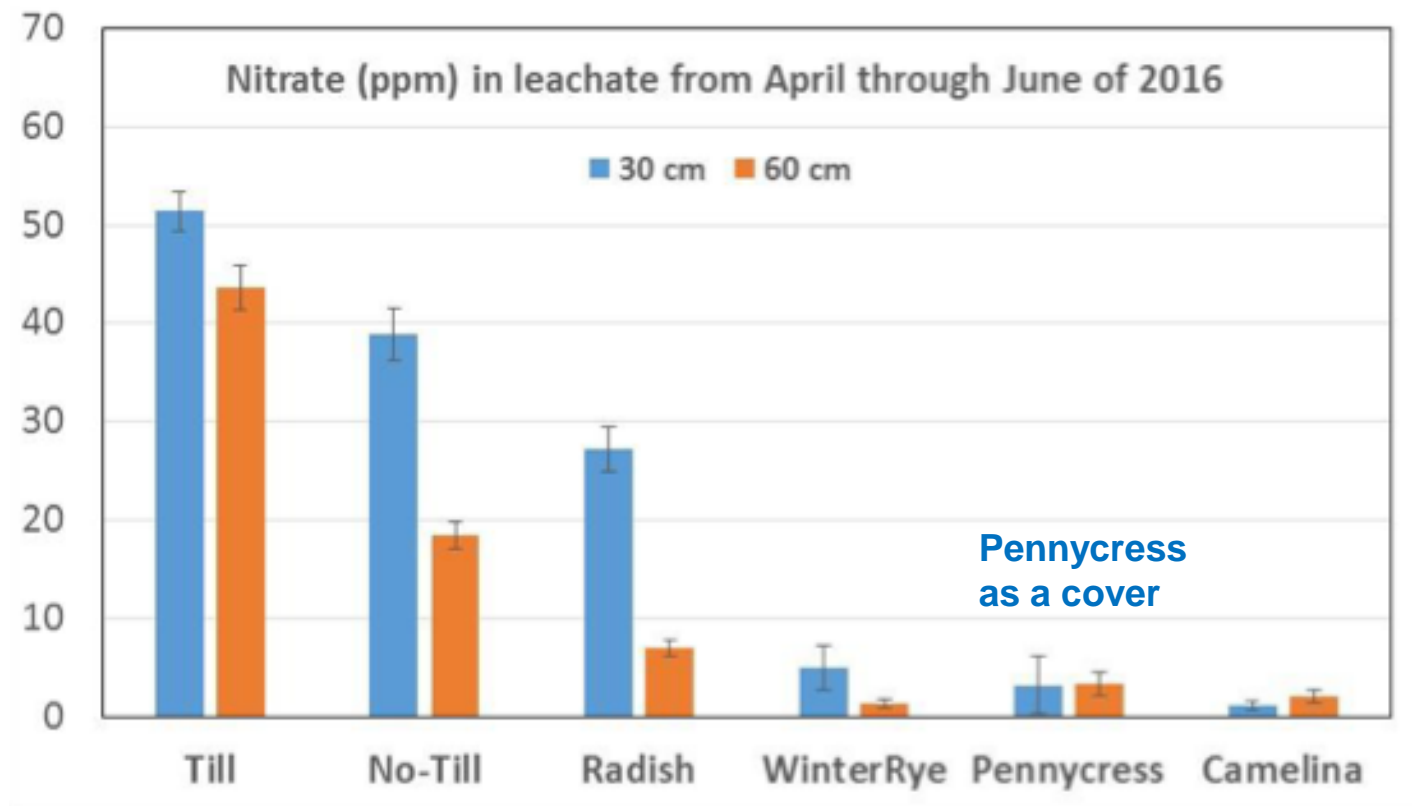
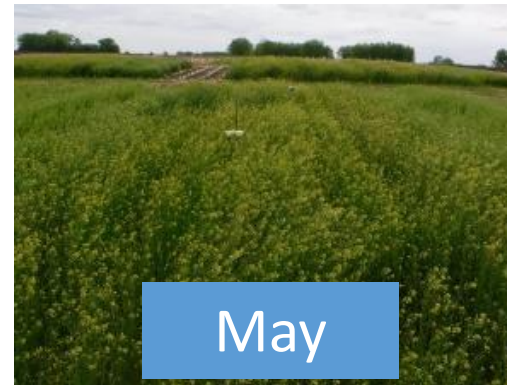


Figure 1. Nitrate levels in leachate from lysimeters placed at 30 and 60 cm soil depths at the Swan Lake Research Farm, Stevens Co., MN. Plots were sown to cover crops and lysimeters installed in September 2015. provided by Dr Frank Forcella, USDA ARS Morris, MN.

Oilseed Cropping System: Ecosystem



Reduce Soil Erosion

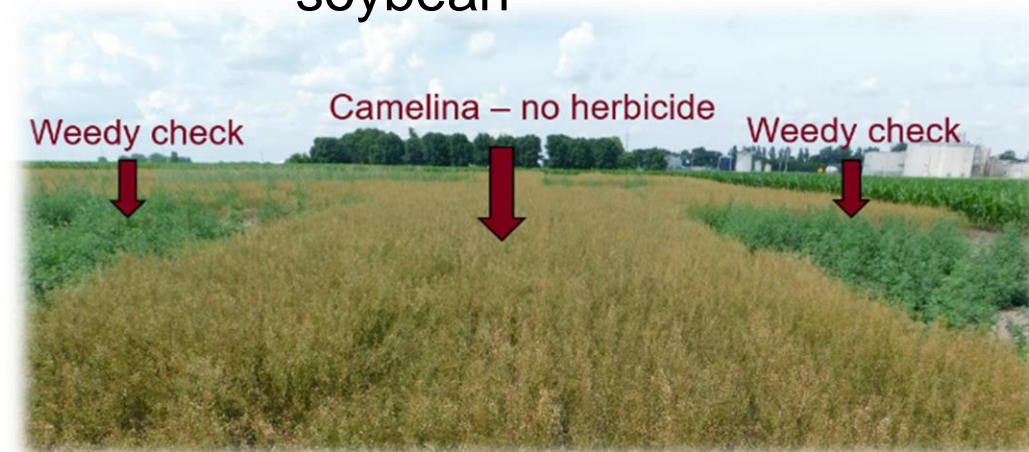


Weyers et al. 2020 J Environ Qual

Winter annual crops reduce herbicide applications by 66%--reducing potential for development of weed resistance to herbicides

Hoerning et al. 2020 Agron J

New method of weed control in soybean





Projected 5-year Outcomes from Proposed Investment

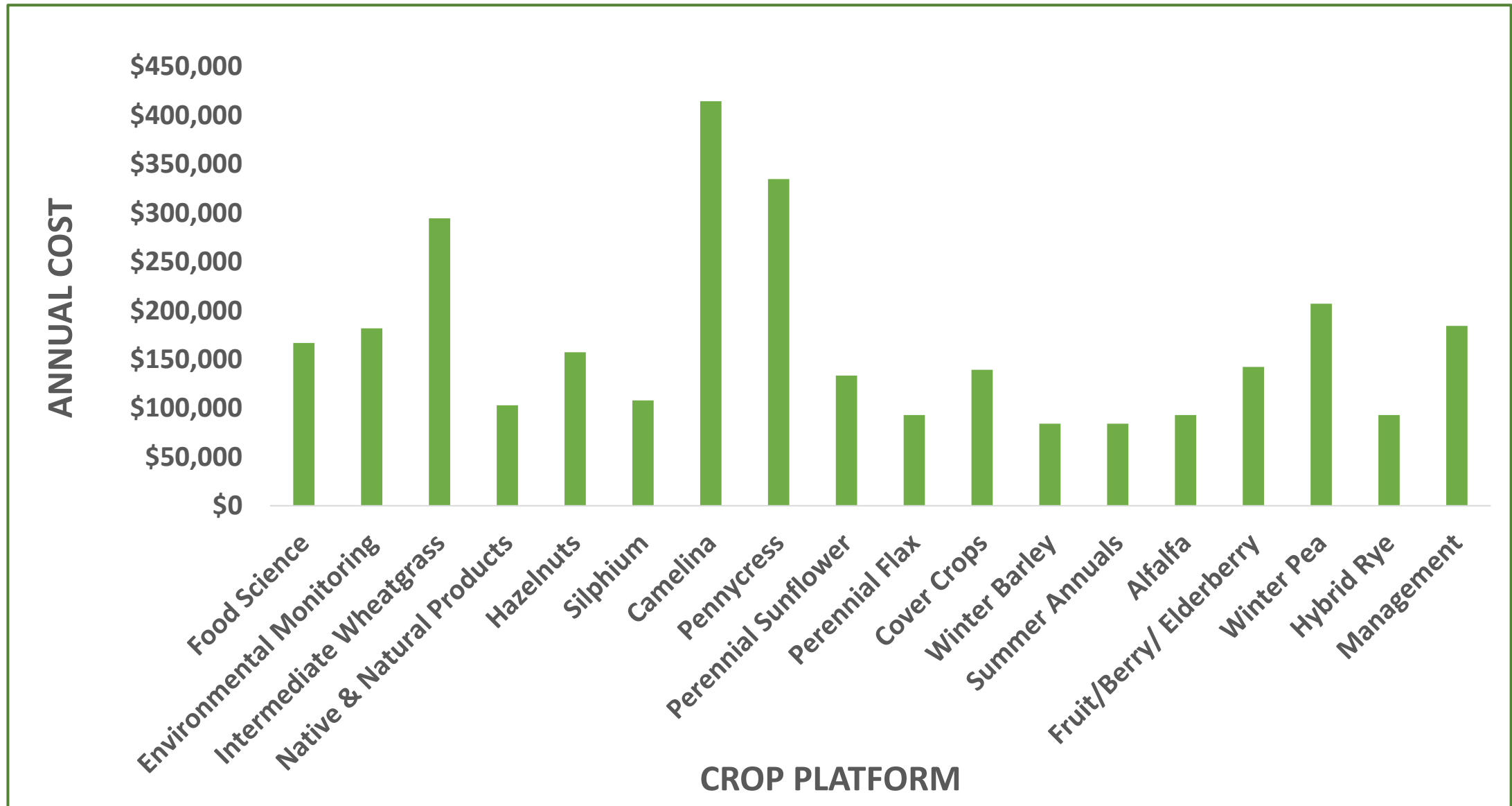
Continued Product Development

- 2 varieties of Kernza for commercialization
- 2 short-season winter camelina varieties for commercialization
- 2 varieties of fully-domesticated pennycress varieties for commercialization
- 10 hazelnut lines for commercialization
- 3 lines of winter hardy field pea for commercial evaluation
- 2 varieties of winter hardy barley for commercialization
- 3 varieties of perennial flax varieties for commercialization

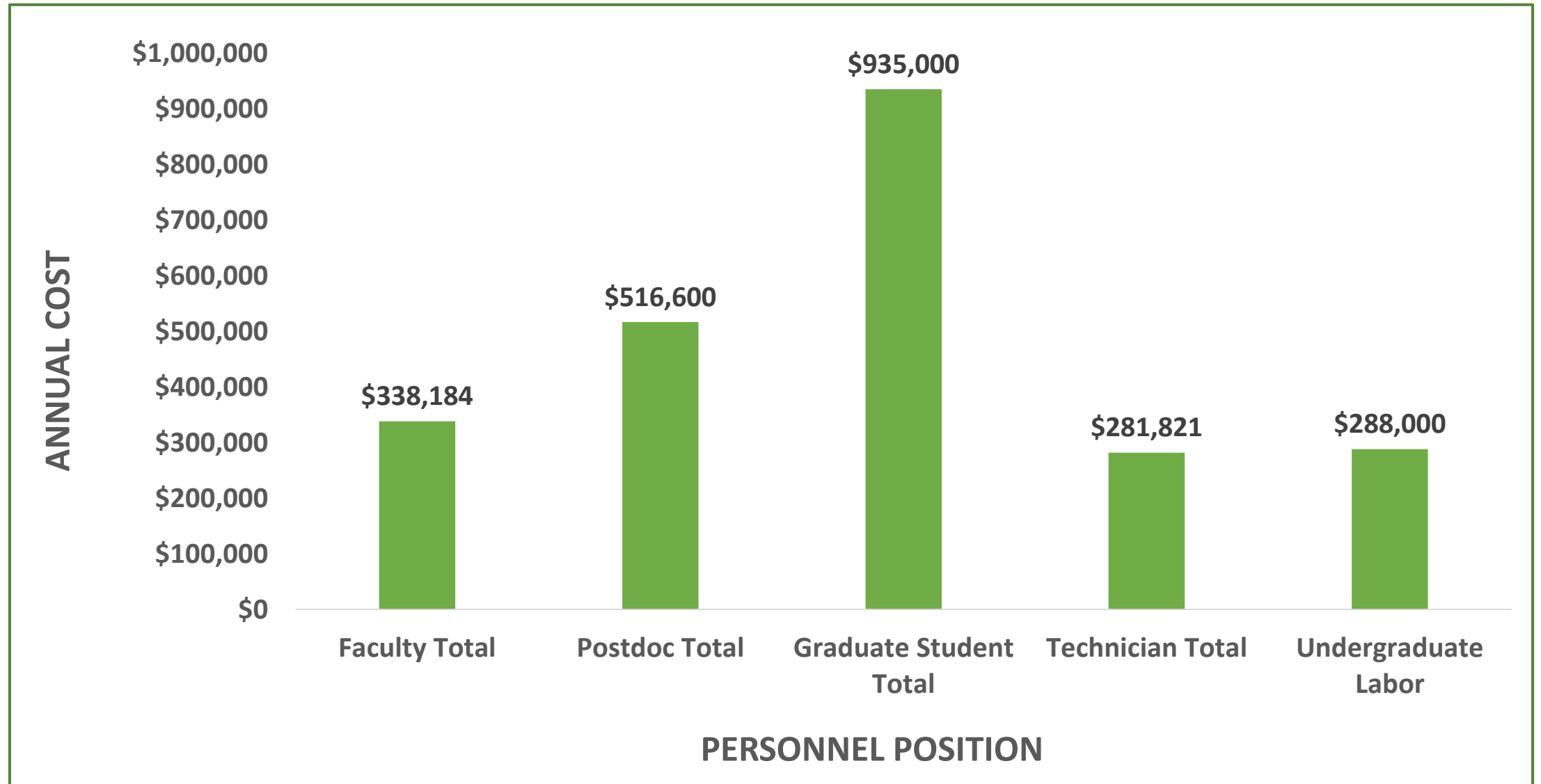
Expanded Collaborations and Cropping Systems

- Expand coordination of FGI with MN communities, seed companies, farmers, grain processors, and commercialization and supply chain network
- Educational and workforce development opportunities for many Undergraduate Students, Graduate Students, Postdoctoral Researchers and Research Technicians to support Agriculture and Food Industry in Minnesota
- Incorporate Forever Green Crops into thousands of acres of cropping systems in Minnesota

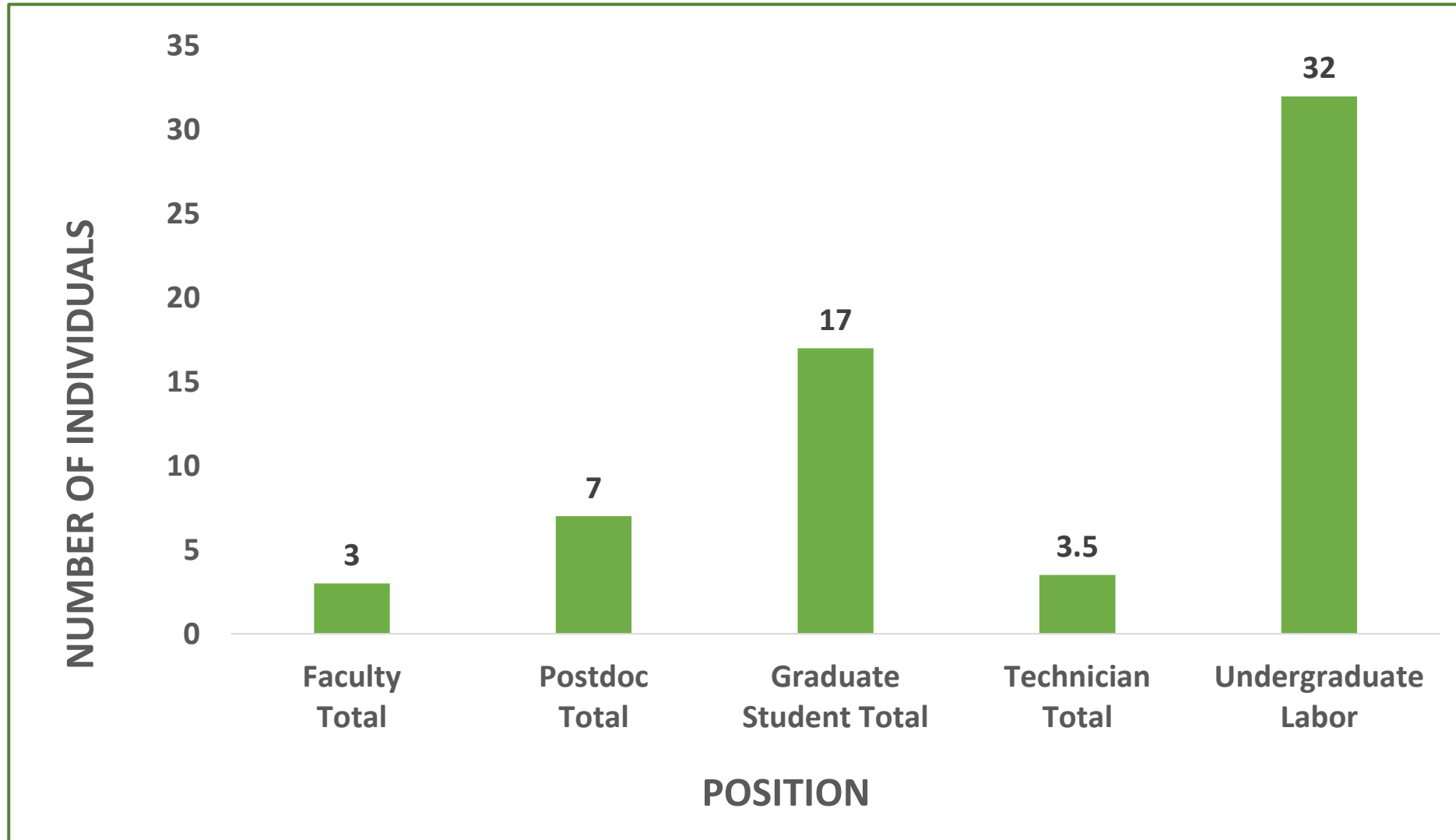
Annual Personnel and Fixed Costs Per Crop



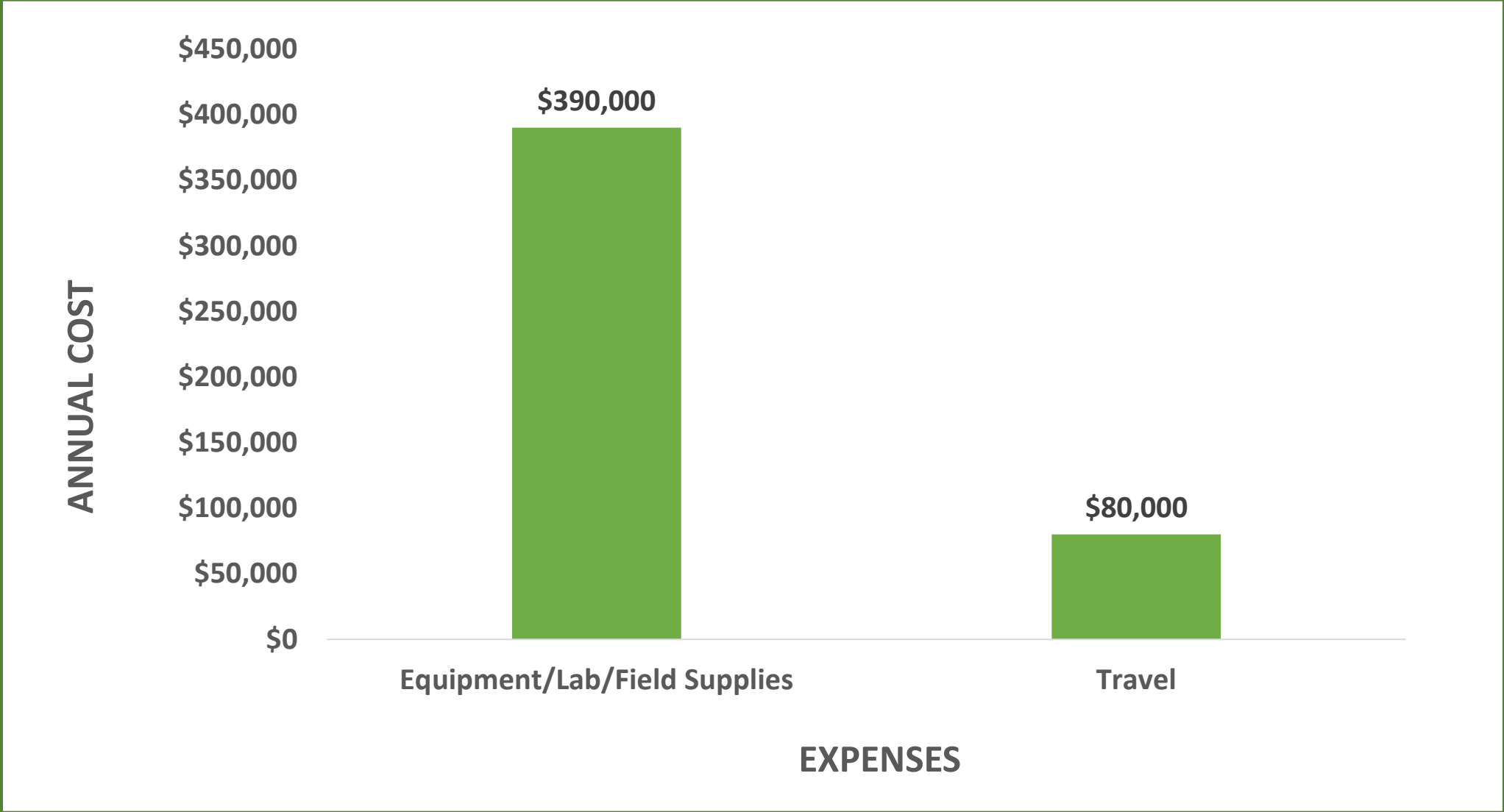
Annual Total Personnel Expenses



Employed Personnel Annually



Annual Travel & Equipment/Lab/Field Expenses



FGI Infrastructure Investment

Priorities:

1. Infrastructure for FGI agronomic research (\$2.4M)
 - Planting equipment
 - Harvesting equipment
 - Equipment transport
2. Sustainable FGI crop breeding and genetics (\$2.6M)
 - Climate controlled crop germplasm preservation facility
 - Environmental plant growth chambers for selection of plant tolerance to weather extremes
3. Forever Green crop seed processing and storage facility (\$0.5M)

Thank you for your support on behalf of everyone associated with The Forever Green Initiative

- Undergraduate students
- Graduate students
- Postdoctoral researchers
- Faculty
- Farmers
- Processors
- End users