Production & economics of dual use intermediate wheatgrass

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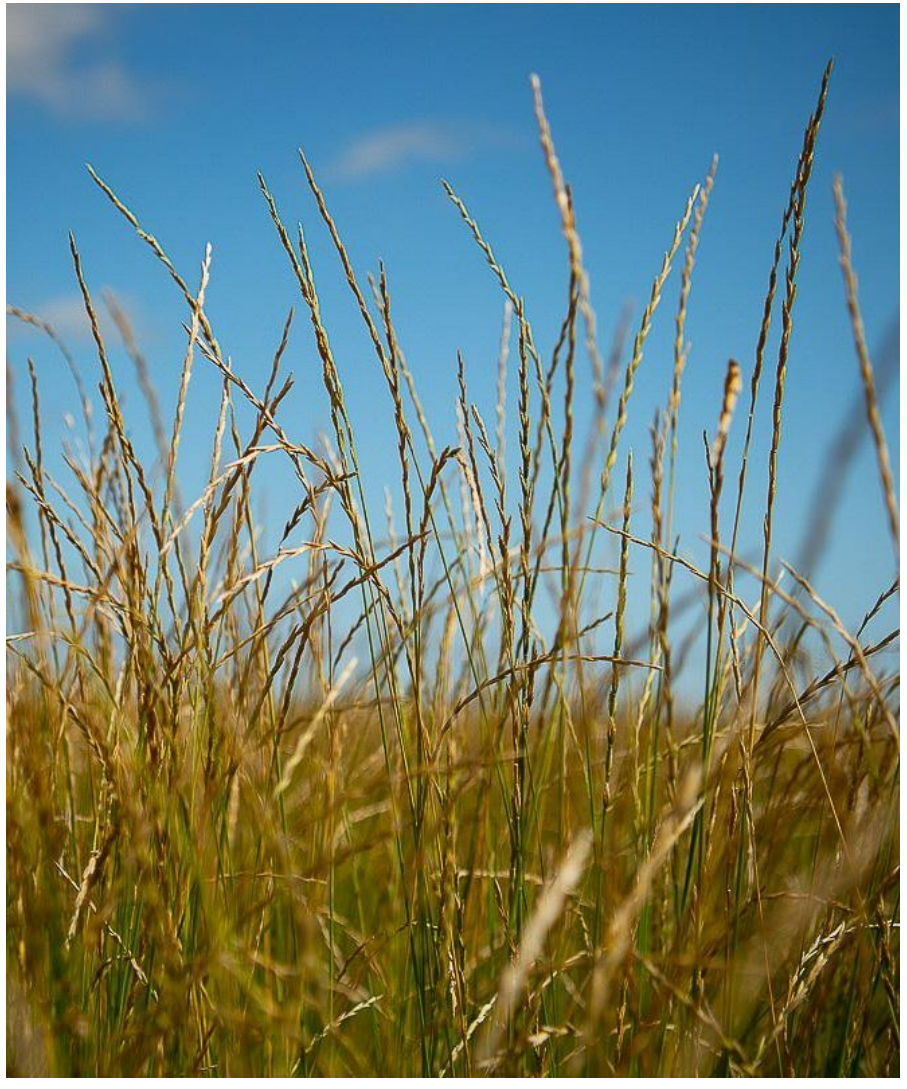
Intermediate wheatgrass (IWG)

[Thinopyrum intermedium (Host) Barkworth & D.R. Dewey]

Kernza ®
IWG grain



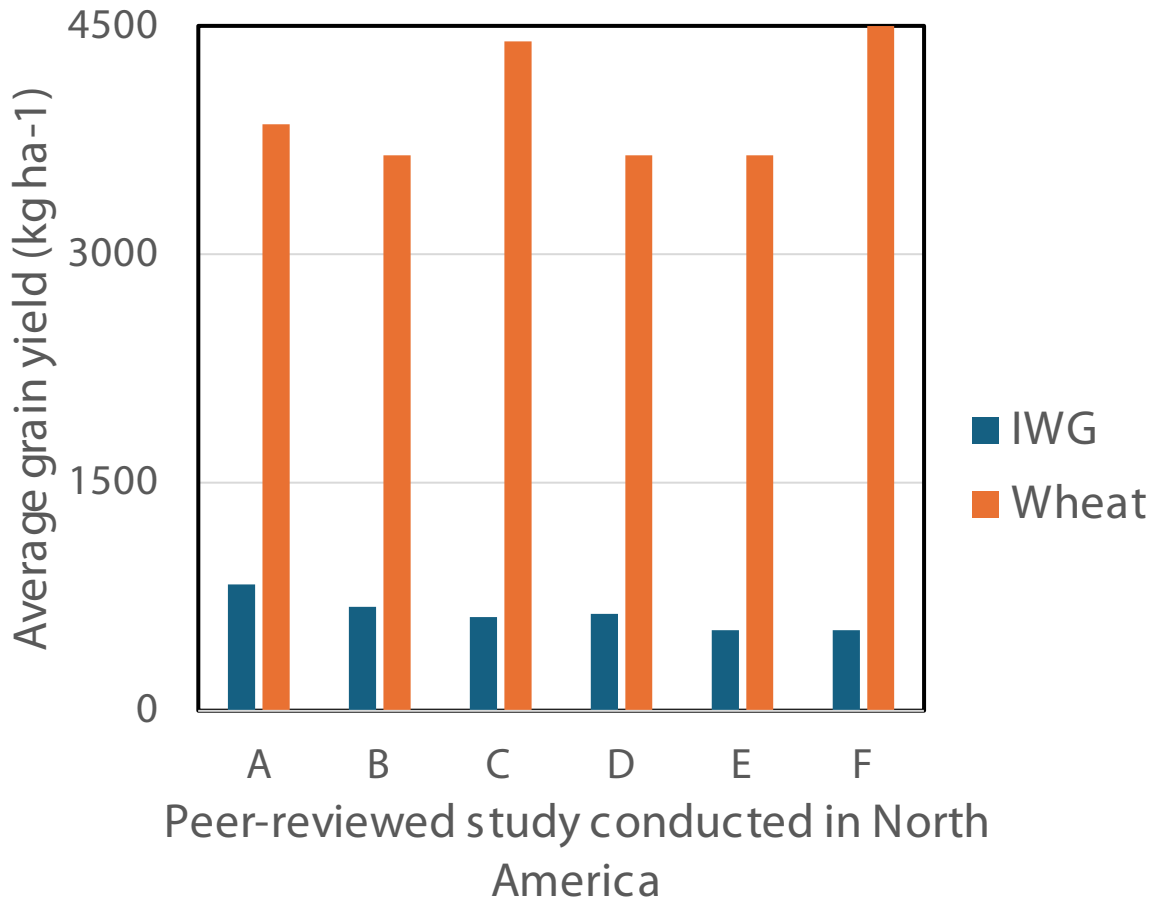
Cool-season perennial forage grass

Perennial grain crop

Photo credits: left, Mitch Hunter; center and right, courtesy of Jacob Jungers

Grain-type IWG domestication progress

Image credit: The Forever Green Initiative



Adapted from Cassman & Connor (2022)

Grain-type IWG cropping system interest

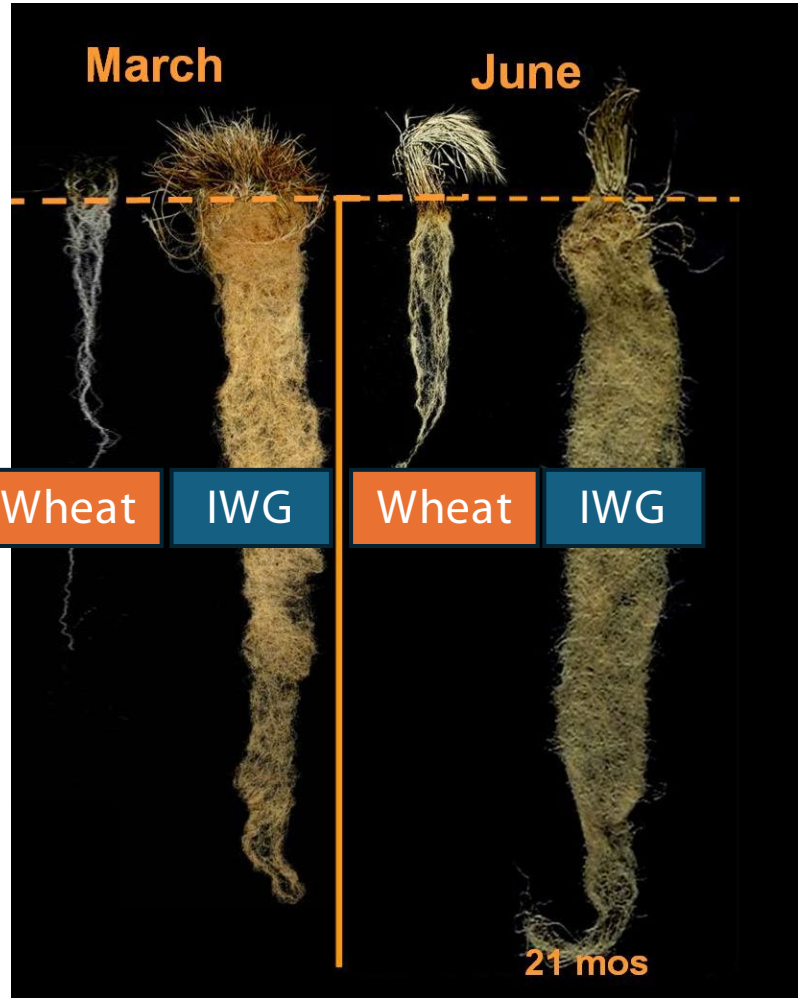
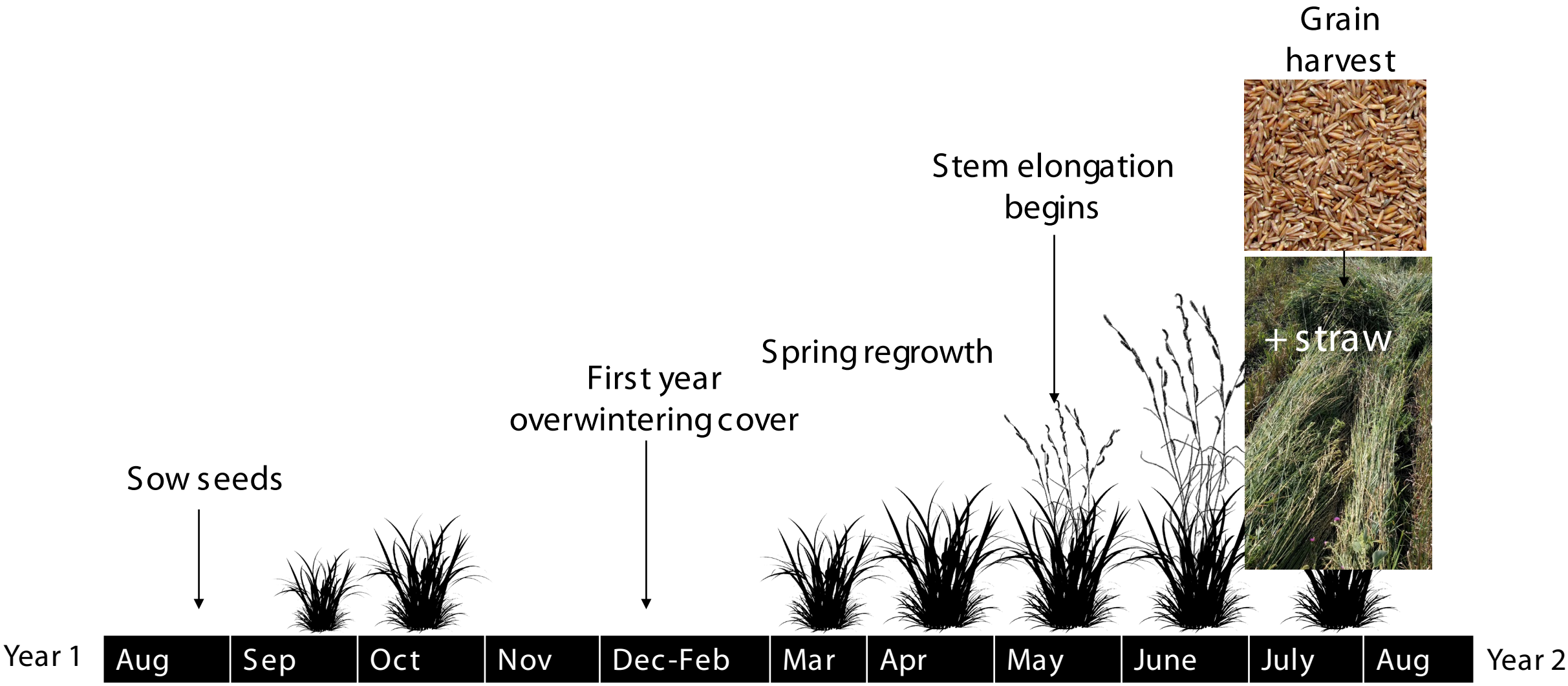


Image courtesy of Jacob Jungers

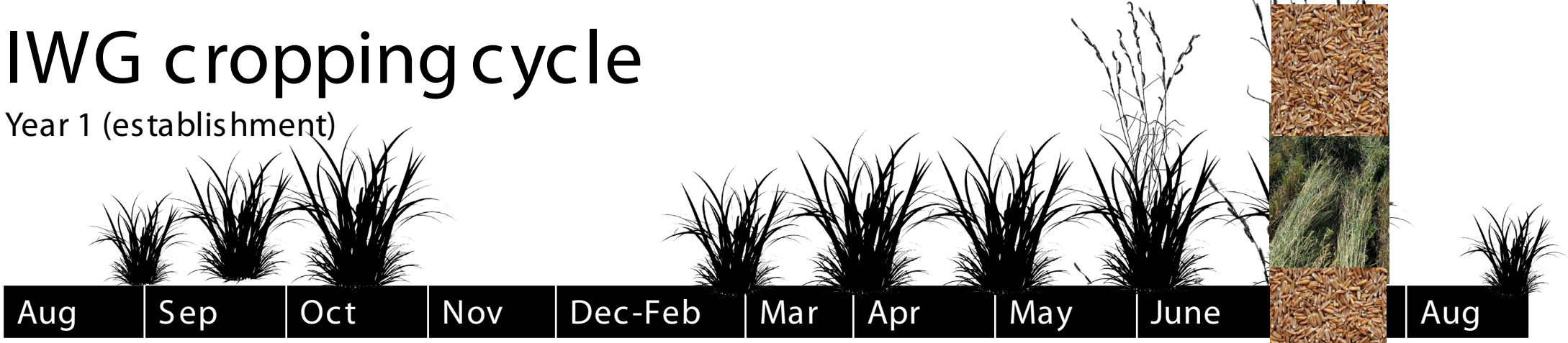
- Prevents soil erosion (Kantar et al., 2016)
- Promotes soil C accrual (van der Pol et al., 2022)
- Reduces nitrate leaching (Reilly et al., 2022; Jungers et al., 2019)
- Fewer inputs than annual crops (Bajgain et al., 2020)
- Earns price premiums (Lanker et al., 2020)

IWG establishment & growth

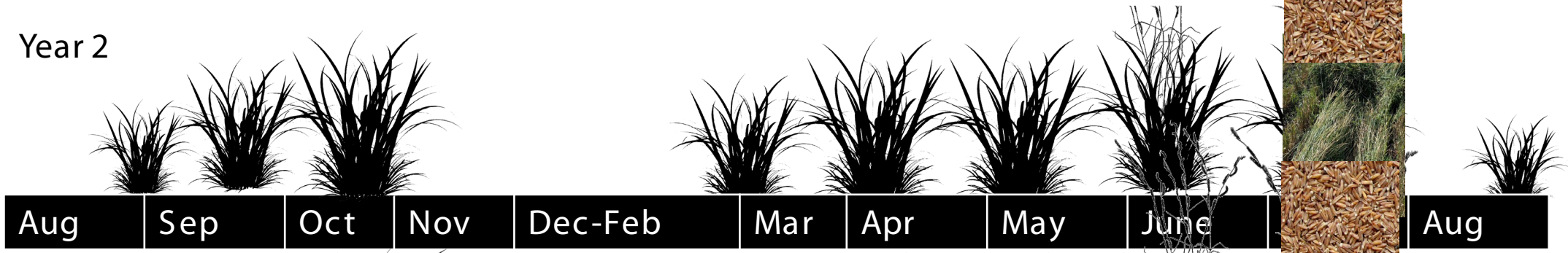


IWG cropping cycle

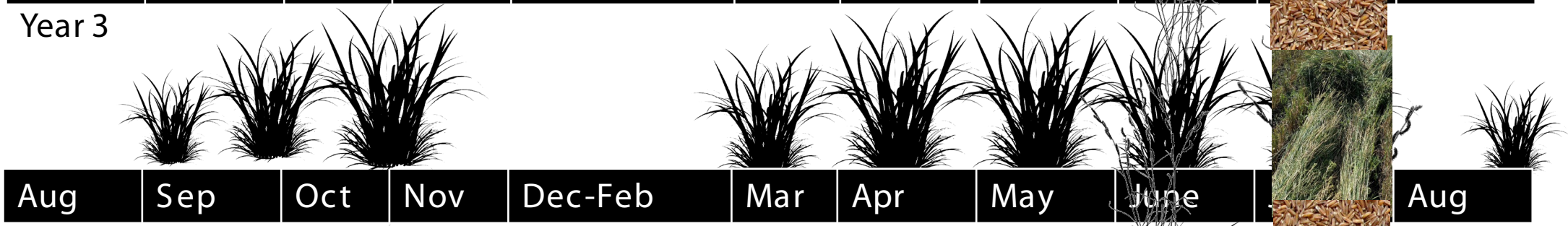
Year 1 (establishment)



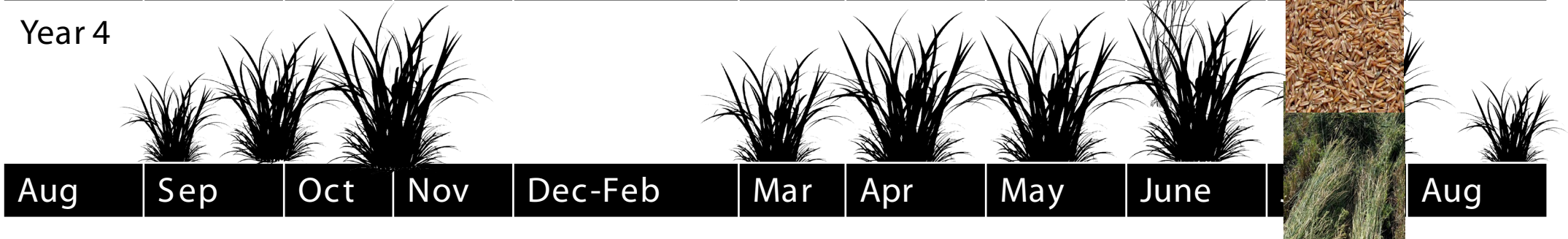
Year 2



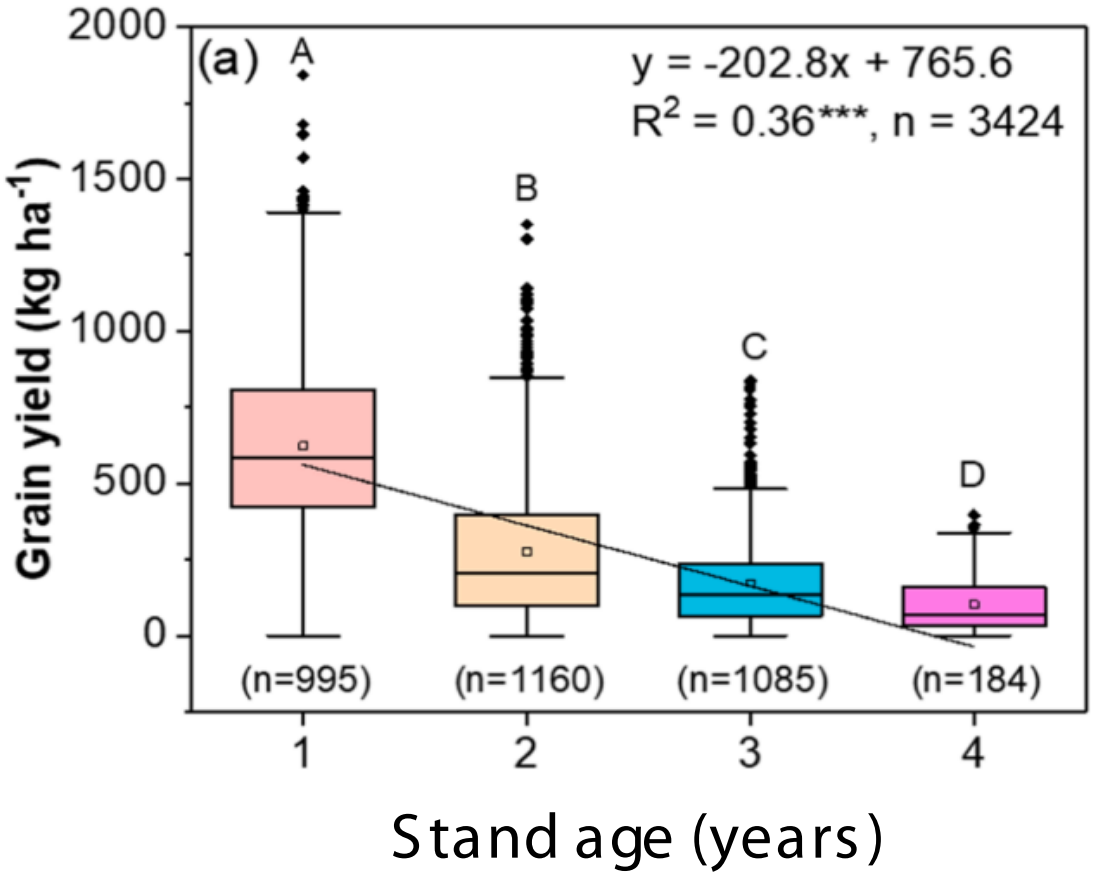
Year 3



Year 4



Grain yields decline as IWG stands mature



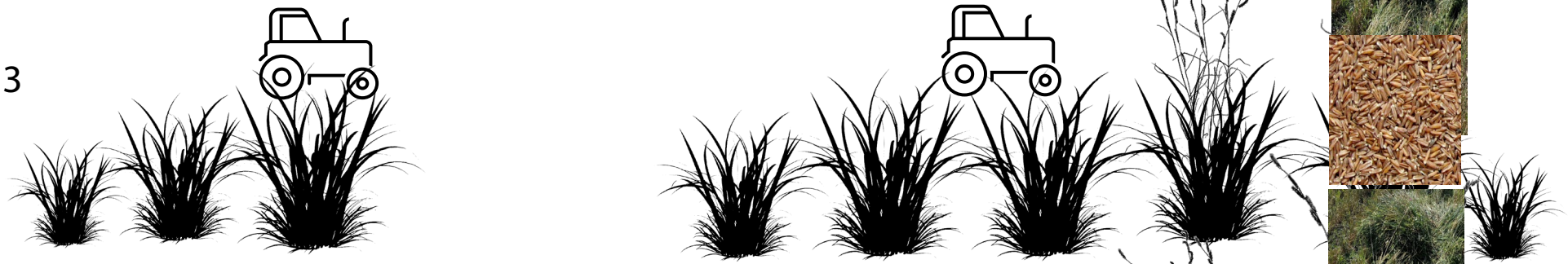
Zhen et al. (2024)

Harvest vegetative growth for hay

Year 2

Aug	Sep	Oct	Nov	Dec-Feb	Mar	Apr	May	June		Aug

Year 3



Aug	Sep	Oct	Nov	Dec-Feb	Mar	Apr	May	June		Aug

Year 4

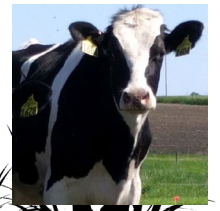
Aug	Sep	Oct	Nov	Dec-Feb	Mar	Apr	May	June		Aug

Product sales include:

1) Grain
2) Straw
3) Hay

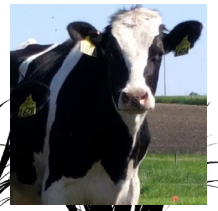
Graze vegetative growth as forage

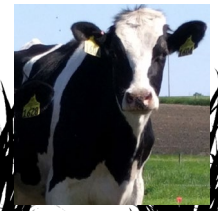
Year 2



Aug | Sep | Oct | Nov | Dec-Feb | Mar | Apr | May | June | Aug

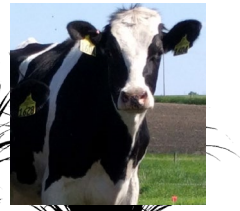
Year 3

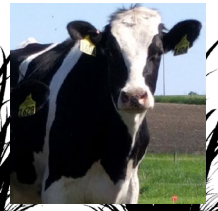




Aug | Sep | Oct | Nov | Dec-Feb | Mar | Apr | May | June | Aug

Year 4





Aug | Sep | Oct | Nov | Dec-Feb | Mar | Apr | May | June | Aug

Product sales include:

1) Grain
2) Straw
3) Forage

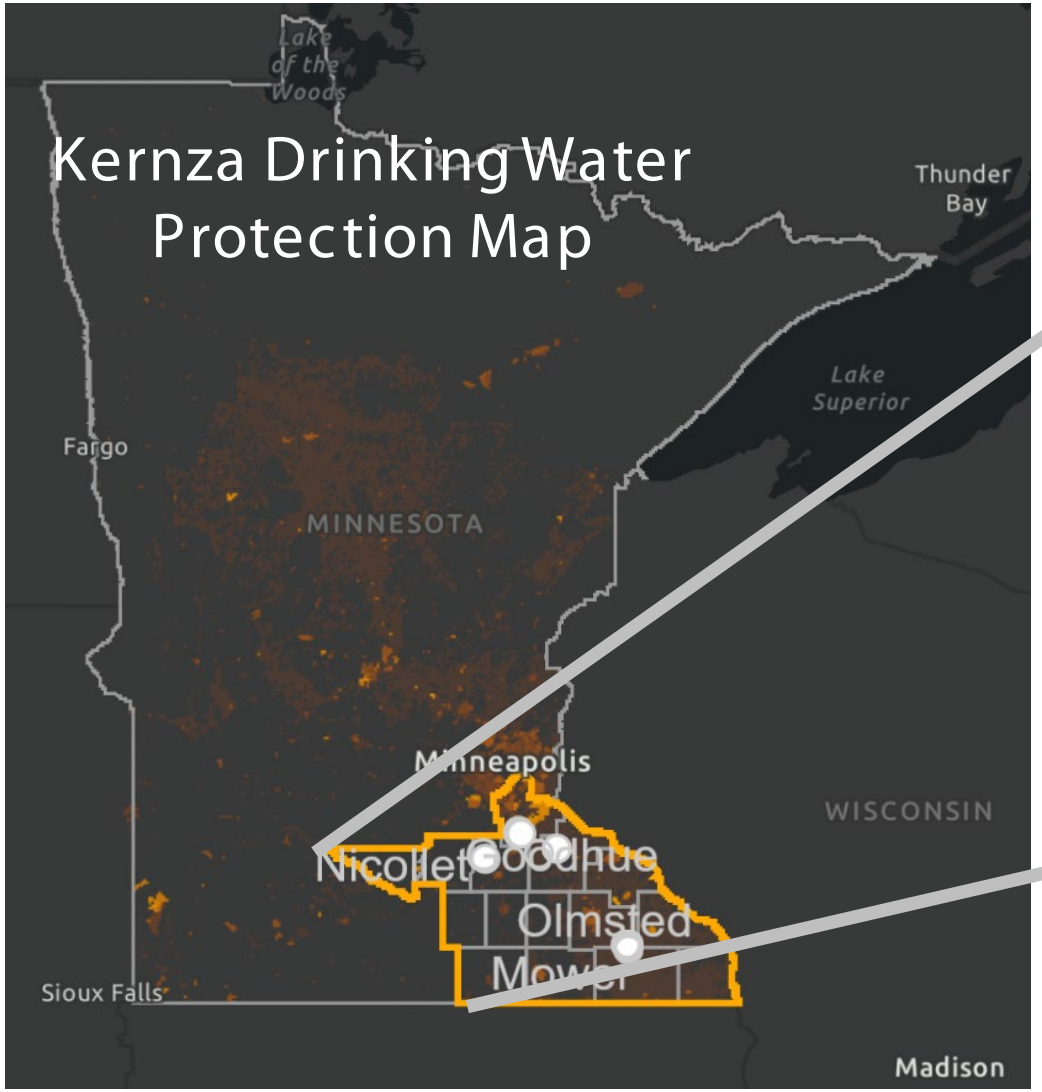
Research objective

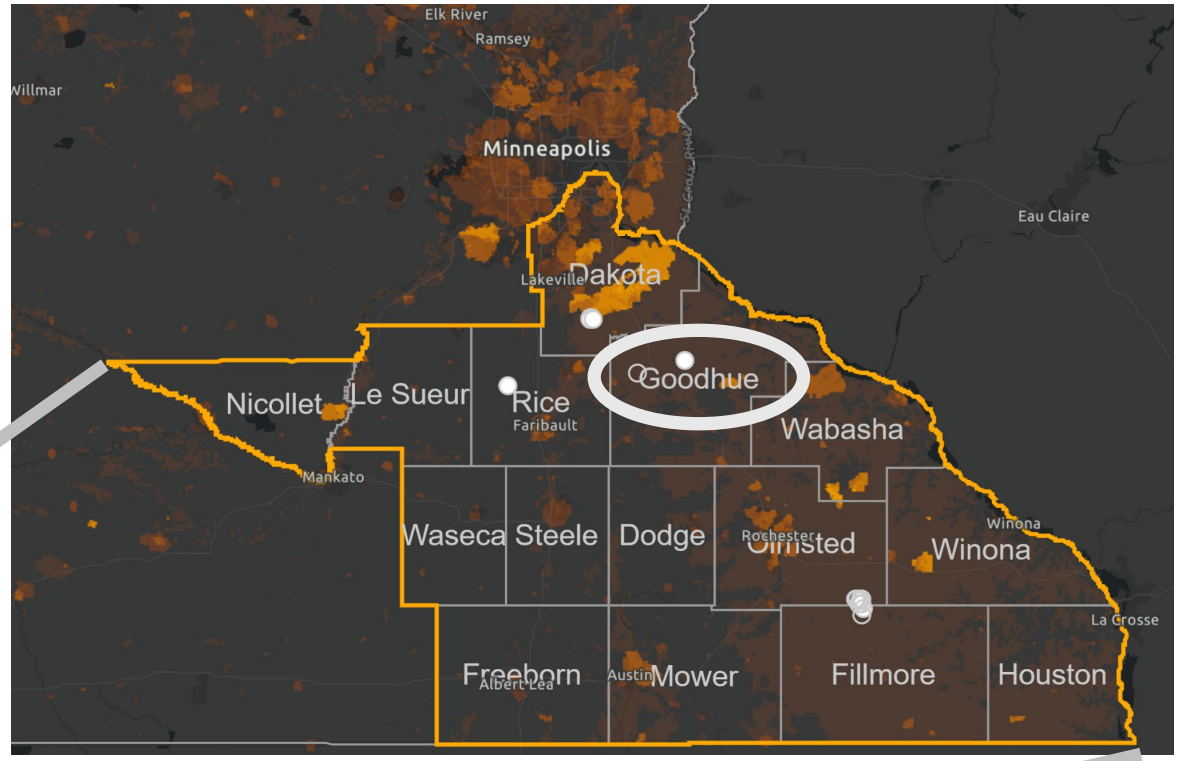
To evaluate the productivity and profitability of grain-type IWG managed as a grain crop vs. as a dual use crop for grain and grazing

Research questions

1) Did grazing reduce grain yields? Straw yields?
2) How did forage yield vary by season among the treatments?
3) Were the net returns for the dual use system similar to or greater than the grain production system?

Materials & Methods



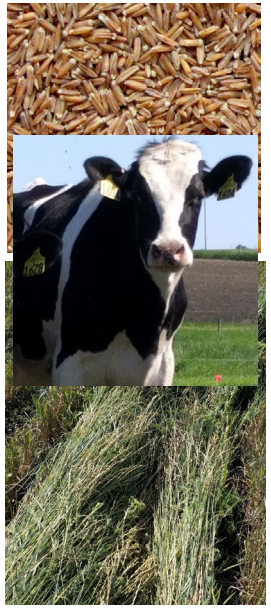


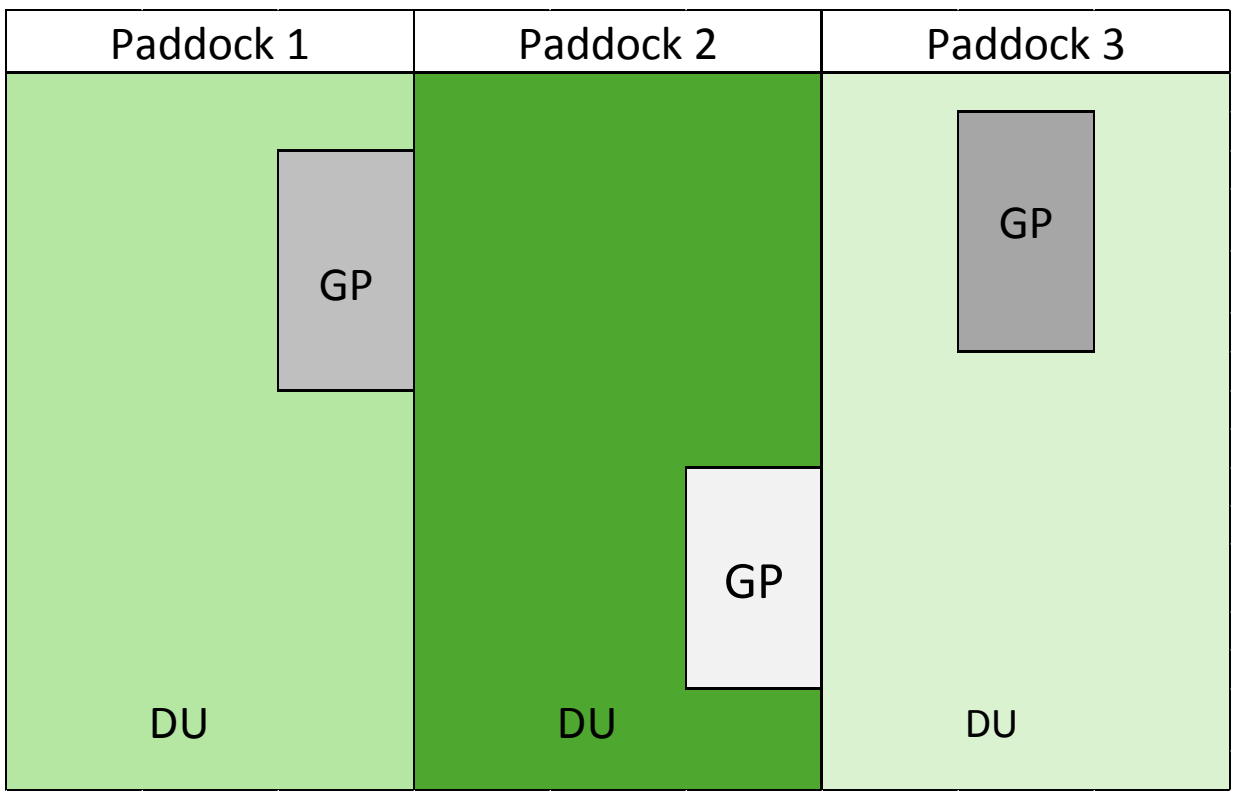
- 4-year on-farm trial established 2018
- Silt-loam soil
- Above-average annual precipitation in years 1 and 2, below average in years 3 and 4

Materials & methods: Experimental design

- RCDB with 3 reps
  - 0.8 ha paddock with 60 m^2 exclosure
- Treatments: Agronomic systems

Grain production (GP) vs. dual use (DU) systems





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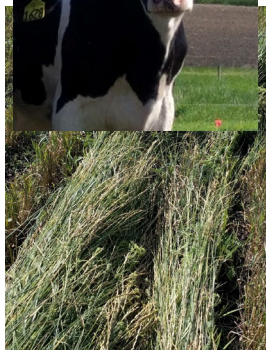
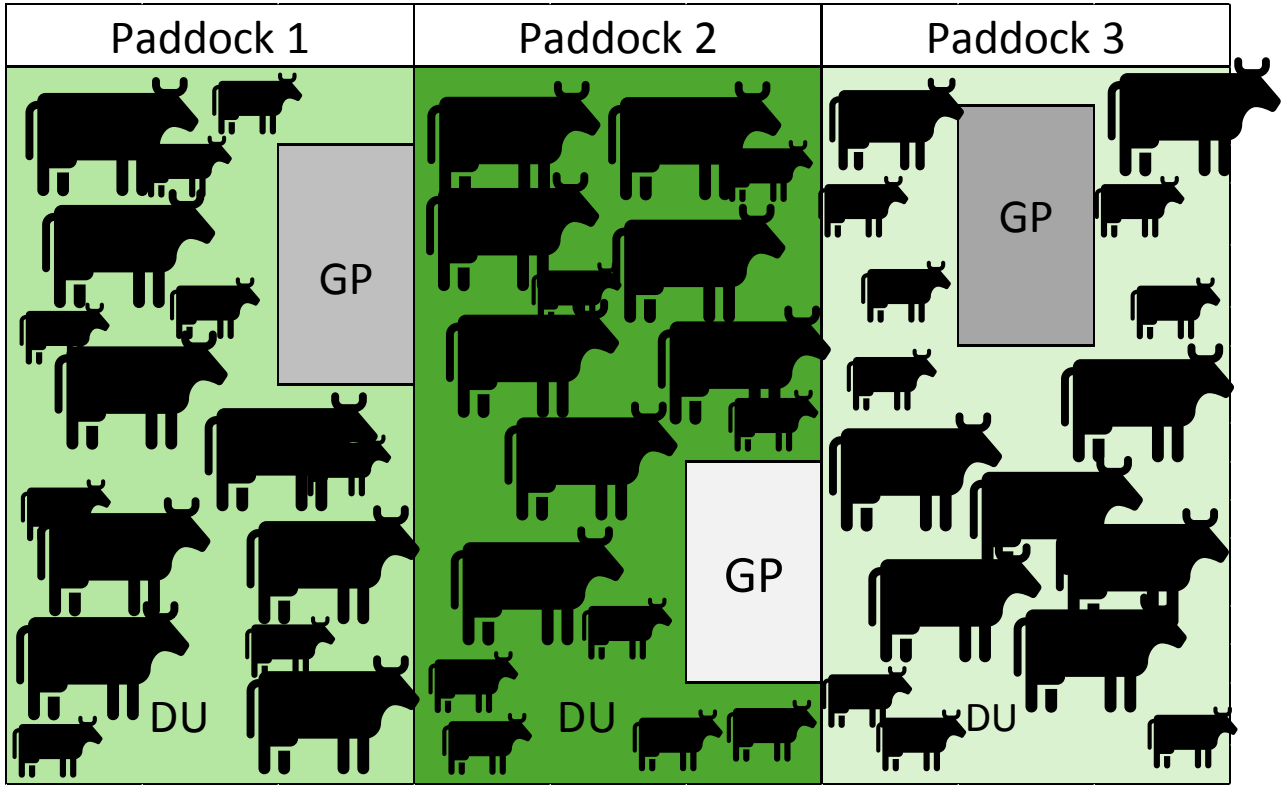
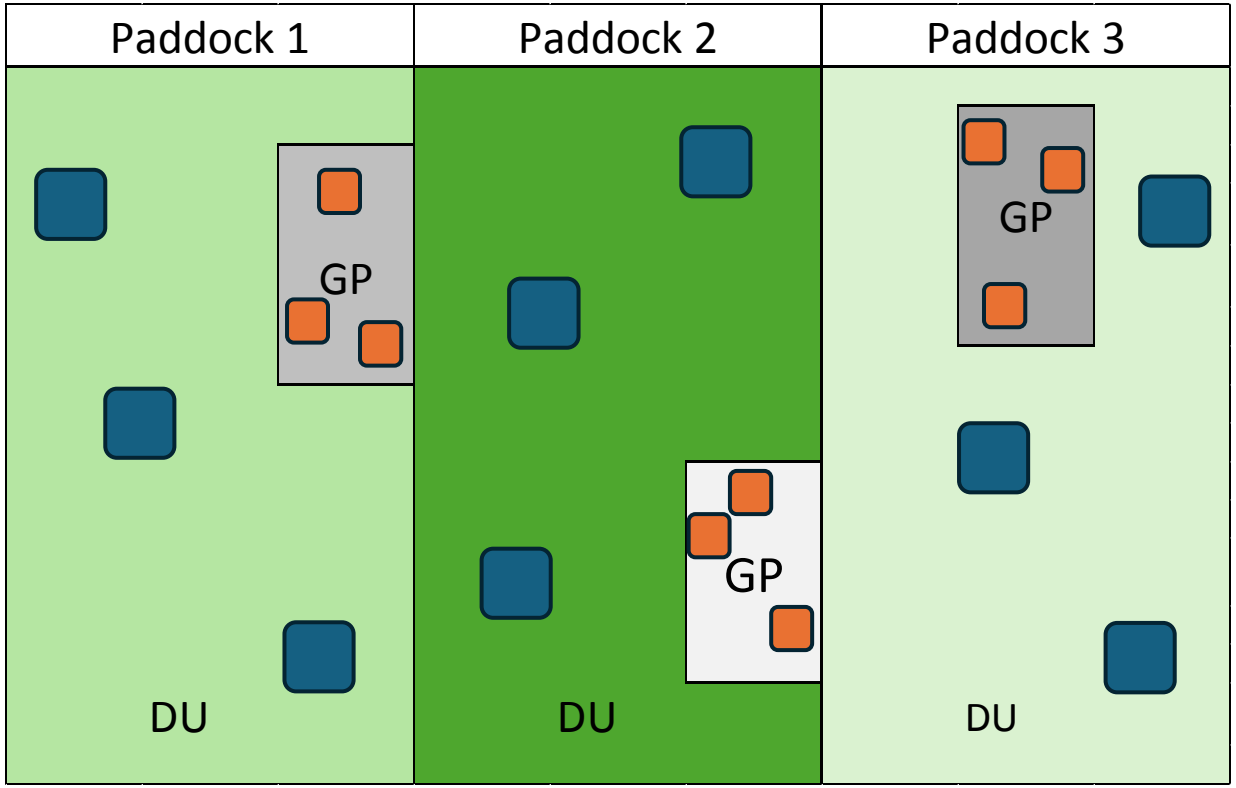




- Mob grazed by 31 cow-calf pairs (~1.7 AU) plus 2 heifers (~1.3 AU each), at a stocking density of 560 kg ha-1, for 5-12d

Materials & methods: Data collection



Farmer expenses and revenues

Pre-graze/ pre-harvest biomass collection

Forage (Nov)

Forage (May)

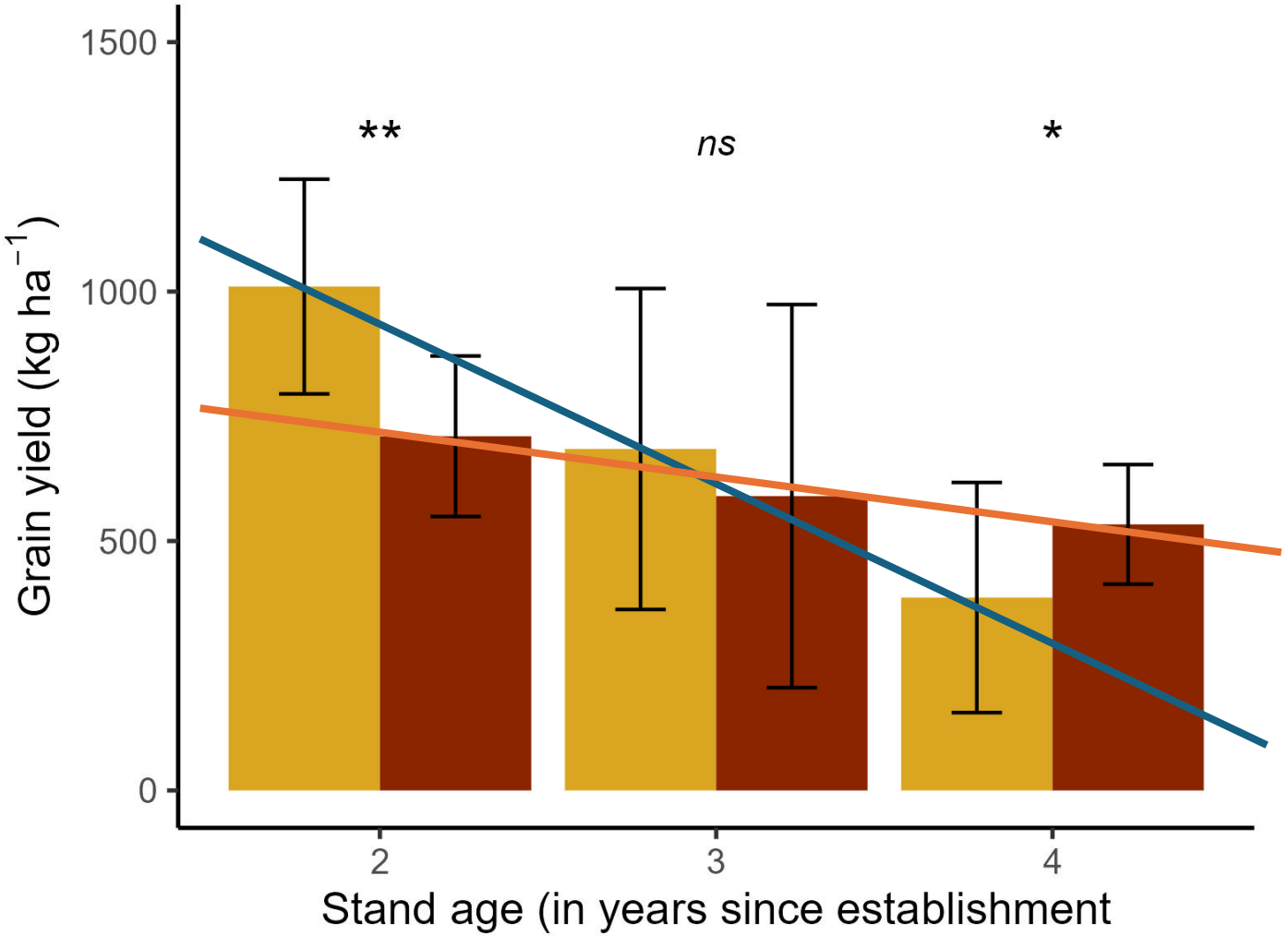
Grain + Straw (July)

Materials & methods: Statistical analysis

- R version 4.3.2 (R Core Team, 2023)
- Linear mixed effects model using nlme package (Pinheiro et al., 2023)
  - Fixed effects: stand age × agronomic system (× season)
  - Random effects: rep × experimental unit
  - Variance function structure (grain yield): stand age
  - Covariance structure (forage yield): season
- Pairwise comparisons of estimated marginal means with emmeans version 1.9.0 (Lenth et al., 2023)

Results

Grazing reduced grain yield in 1 out of 3 years



Agronomic system

Grain production

Dual use

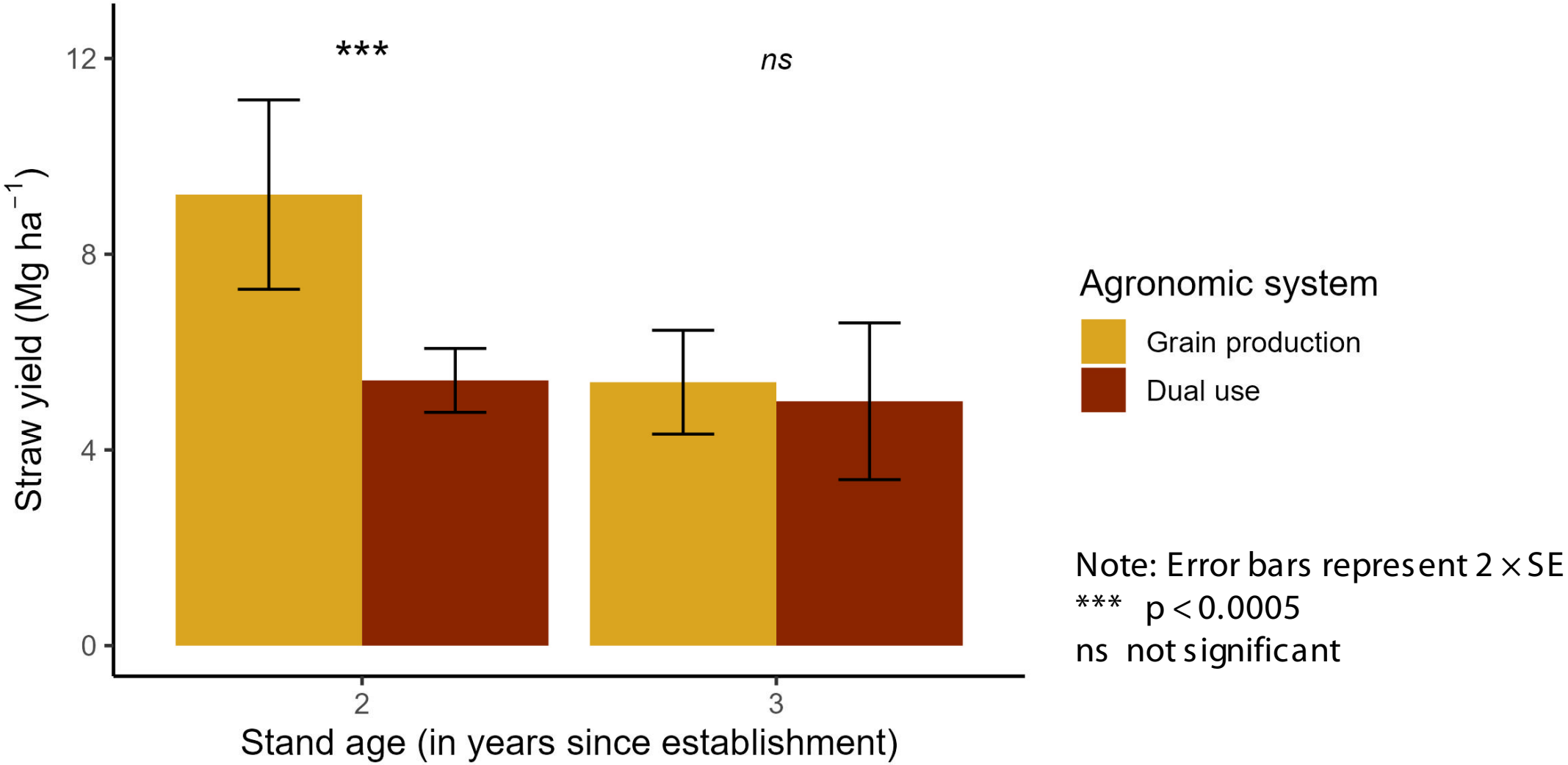
Note: Error bars represent 2 × SE

** $p < 0.005$

* $p < 0.05$

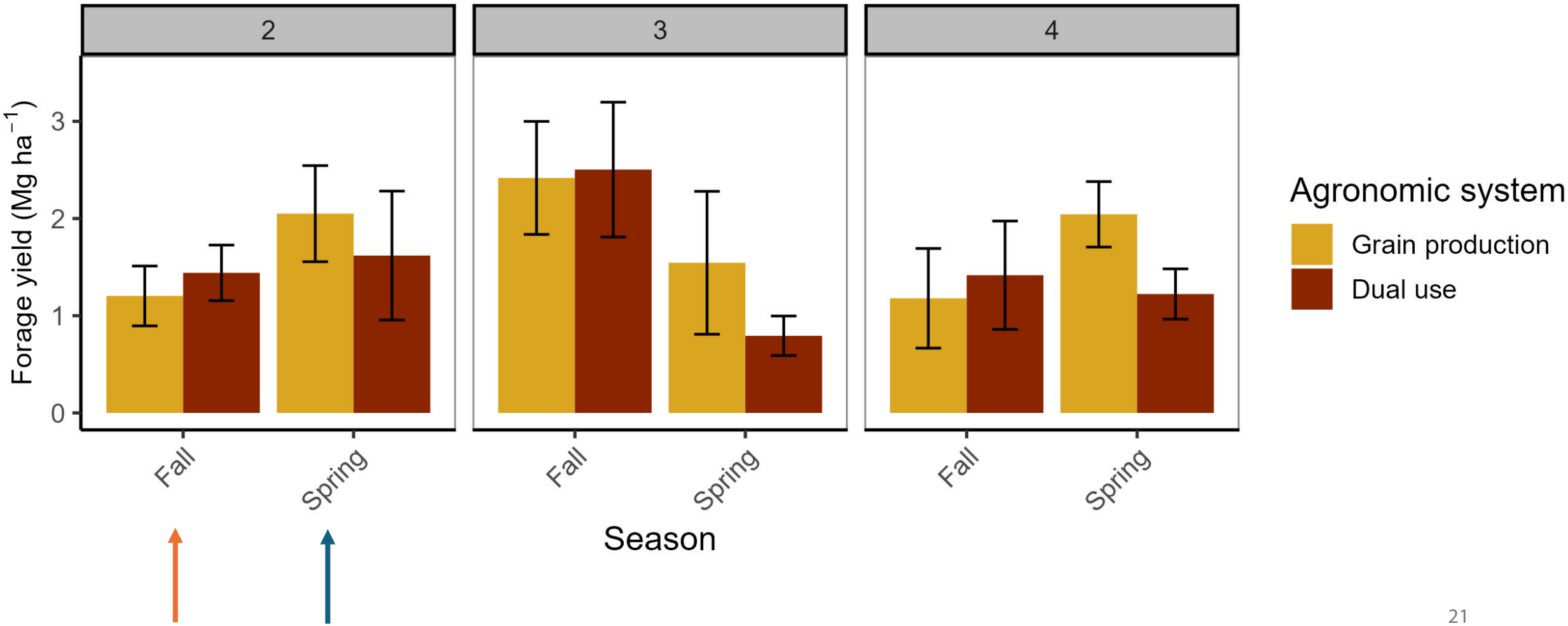
ns not significant

Straw yield trends reflected grain yield

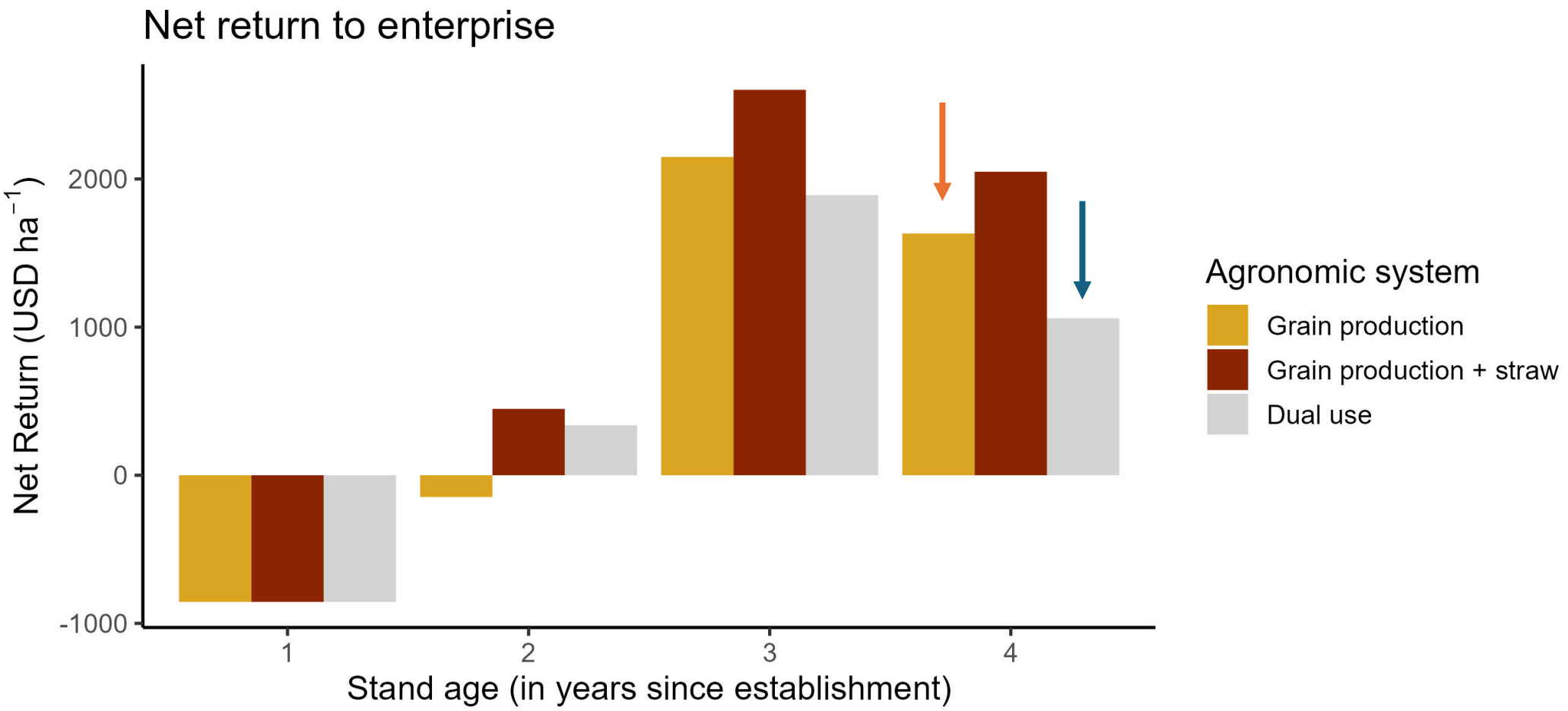


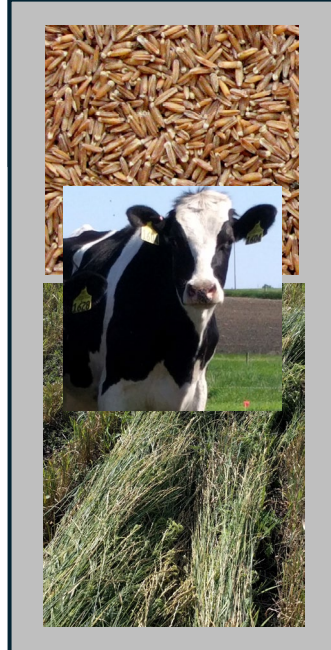
Note: Error bars represent 2 × SE
*** $p < 0.0005$
ns not significant

Forage yields similar among agronomic systems



Straw and forage sales contributed to profits by year 2

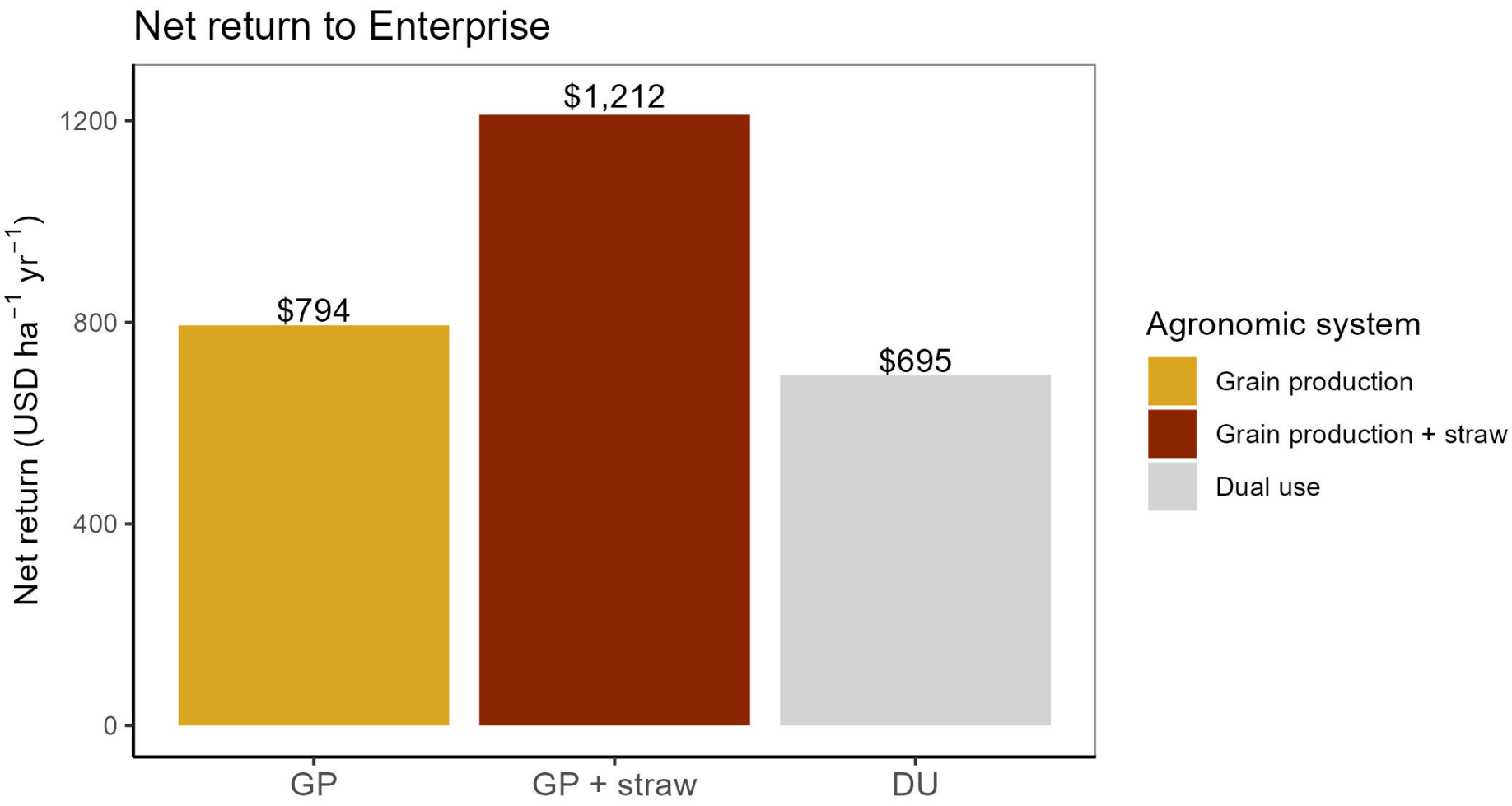




Grain production only had lowest revenues

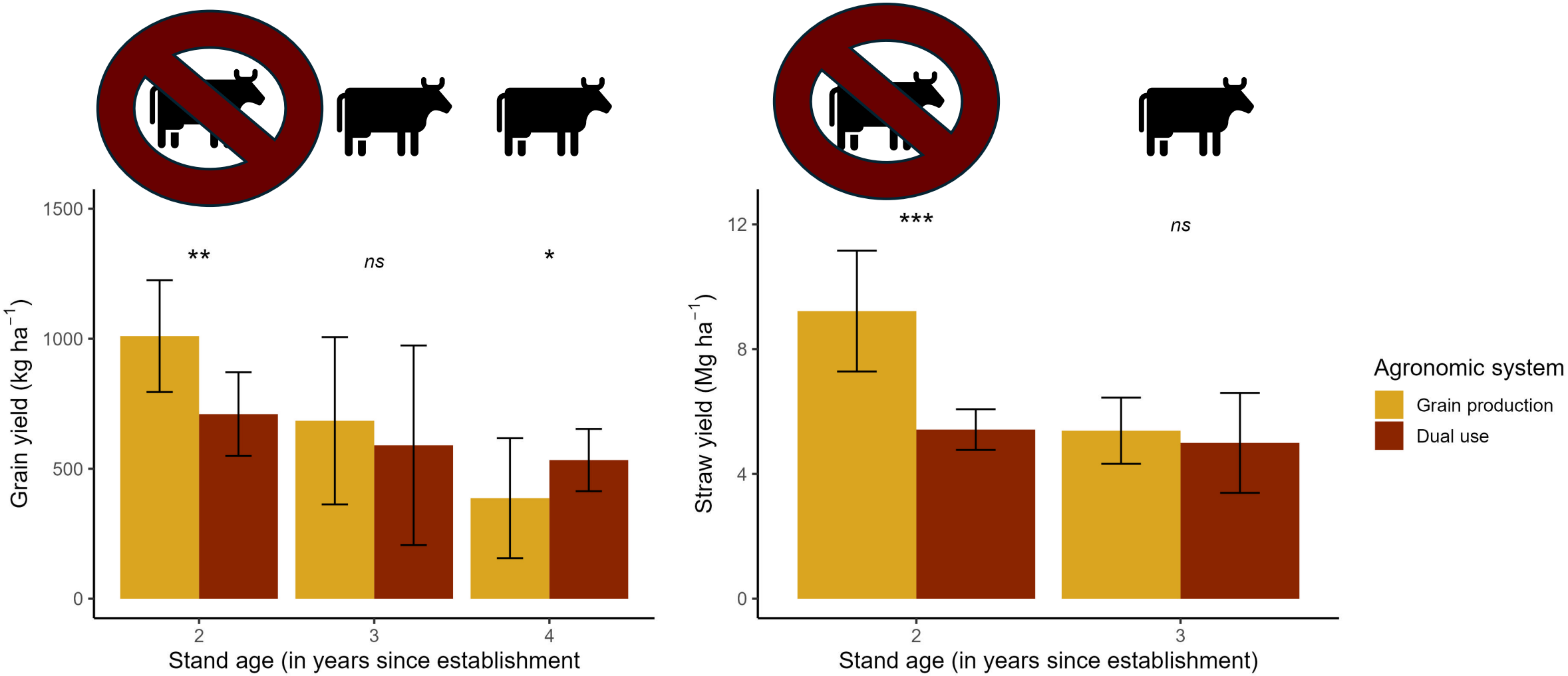
Yields & Revenue	Grain only	Grain+Straw	Dual Use	
	ha-1 yr-1			
Grain, kg total uncleaned	615	615	434	
Grain Sold (total value, 2019=$2.20 kg-1; 2020, 2021= $3.30 kg-1)	$1,907	$1,907	$1,310	**- 597**
Straw, kg total 83% dry matter, avg RFV=80	0	5,114	5,114	
Straw (total value, $0.11 kg-1 as fed)	$0	$563	$563	**+ 563**
Grazed Forage, kg total dry matter, avg RFV=106	0	0	1,483	
Grazed Forage (total value, $0.15 kg-1 dry matter)	$0	$0	$222	**+ 222**
Total Revenue	$1,907	$2,469	$2,094	

Grain+straw production generated greatest profit

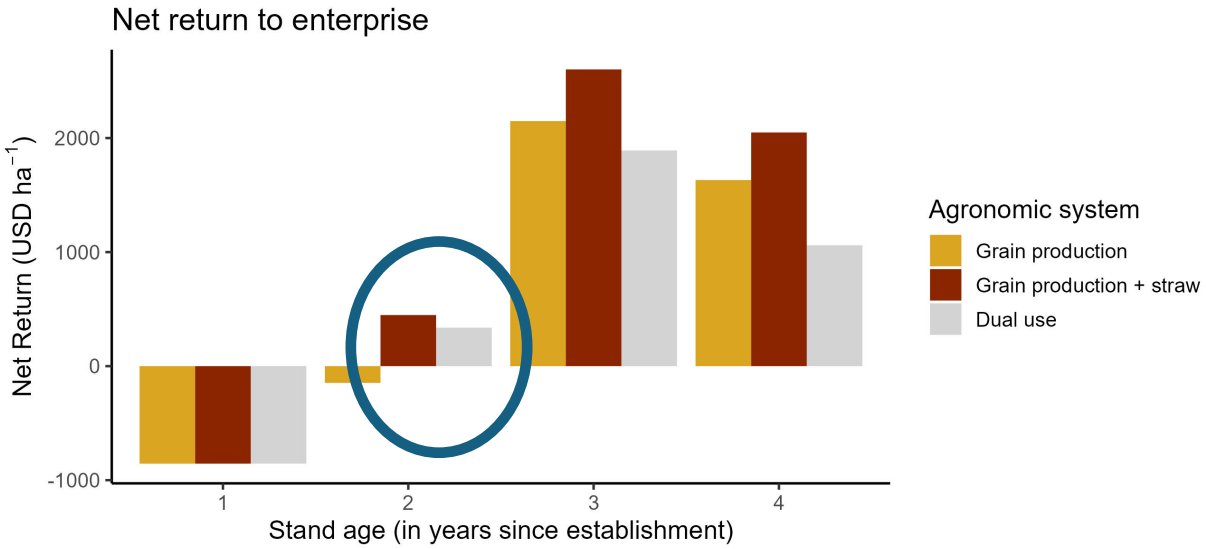


Conclusions

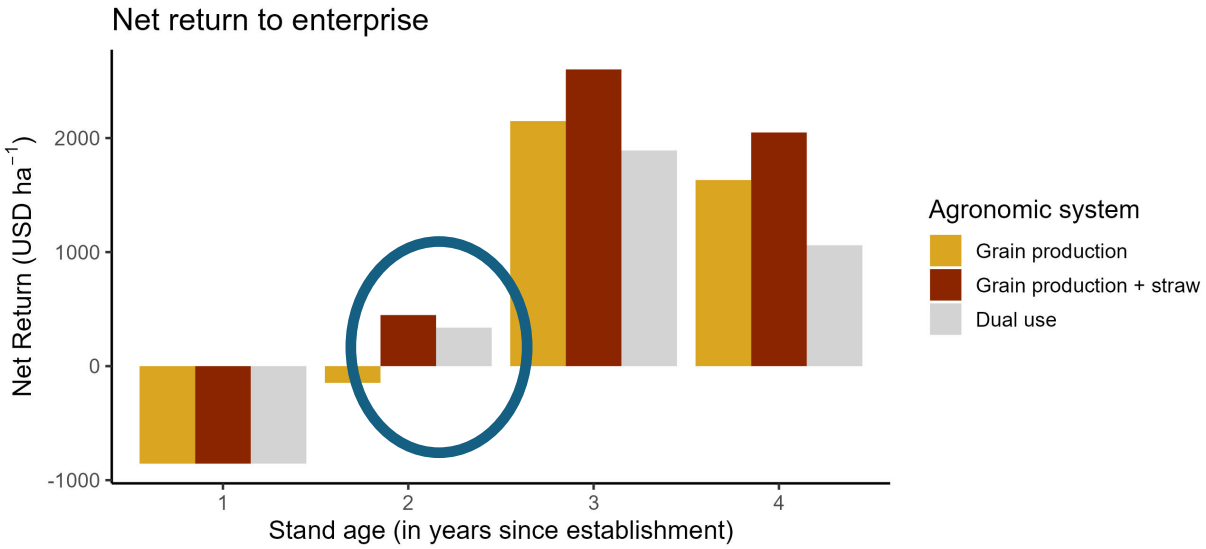
1) Delay grazing to prevent grain and straw yield declines

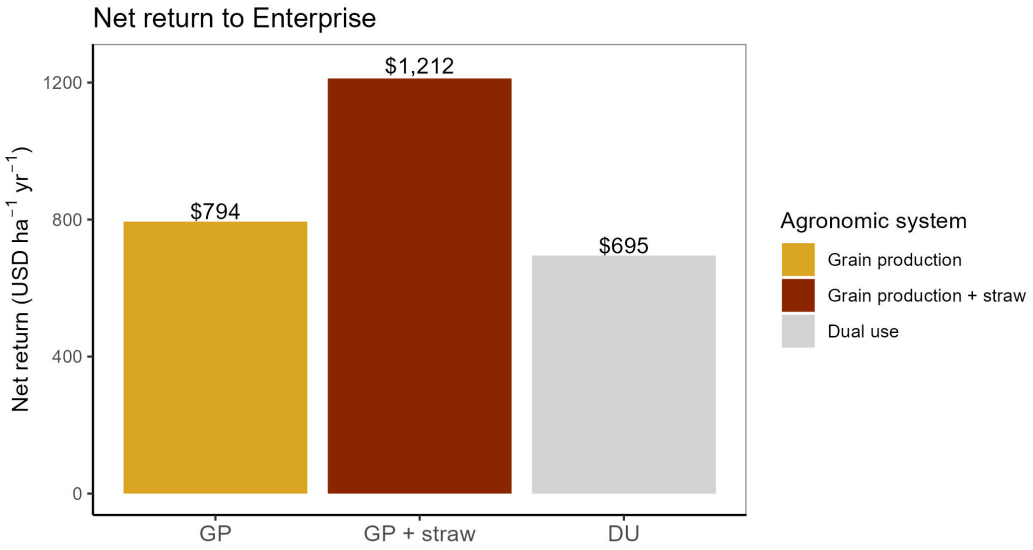


. . although DU was profitable in year 2



2) Straw sales contributed to earlier and greater net returns





4) DU may be undervalued due to incomplete accounting

4) DU may be best suited to operations that already have cattle

Other findings for nutritive value, herbage intake, forage utilization not presented today

Image retrieved on 6/19/2024 from: https://sustainablecropping.umn.edu/kernza-wellhead-mapping-story

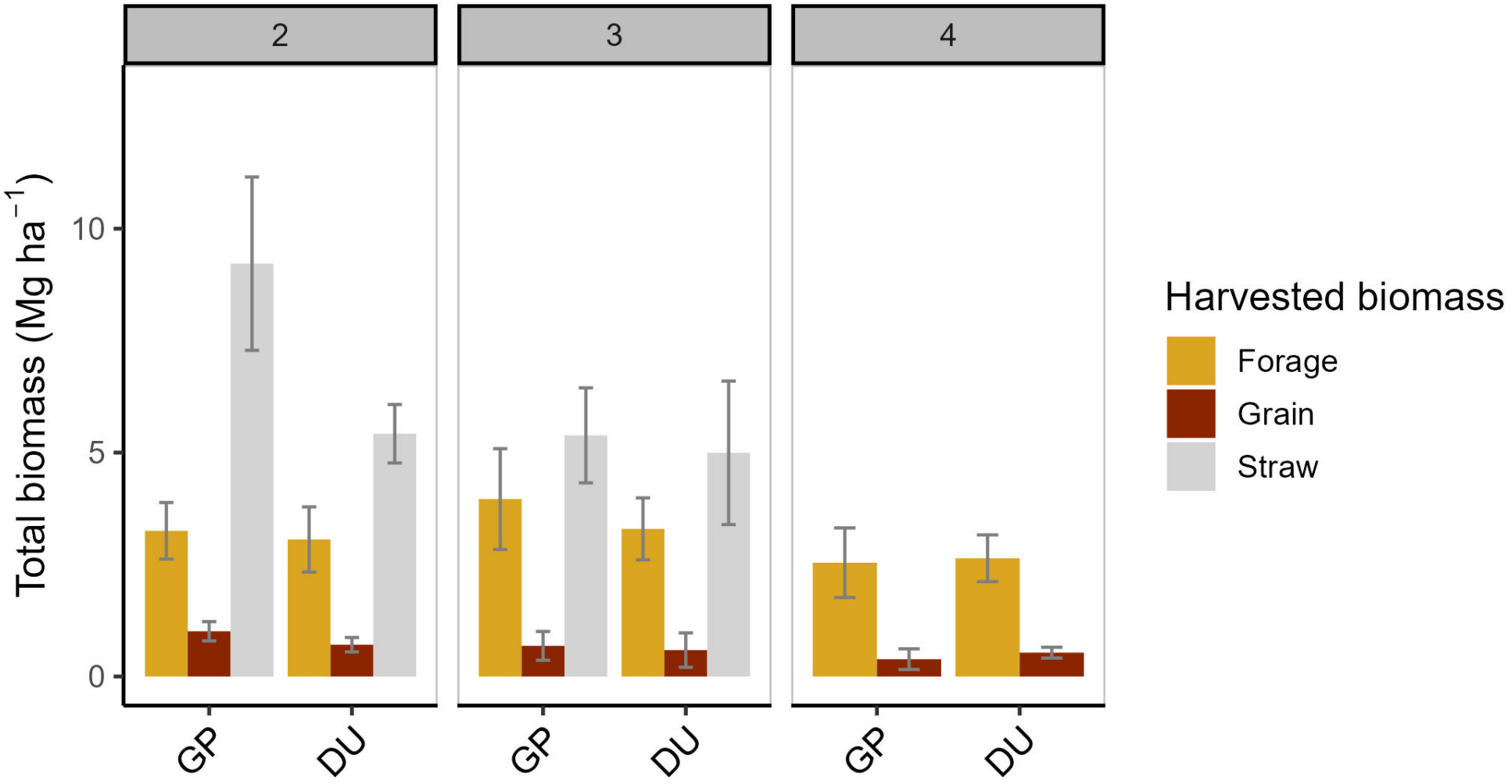
Acknowledgements

- Funding: MDA Sustainable Agriculture Demonstration Grant
- Project leads: Dr. Jacob Jungers, Dr. Mitch Hunter, Dr. Nicole Tautges, Mr. Alan Kraus
- Field technicians: Jesse Puka-Beals, Dane McKittrick, Loren Dauer, and the Sustainable Cropping Systems Lab at the University of Minnesota
- Farmer collaborator: Kaleb Anderson

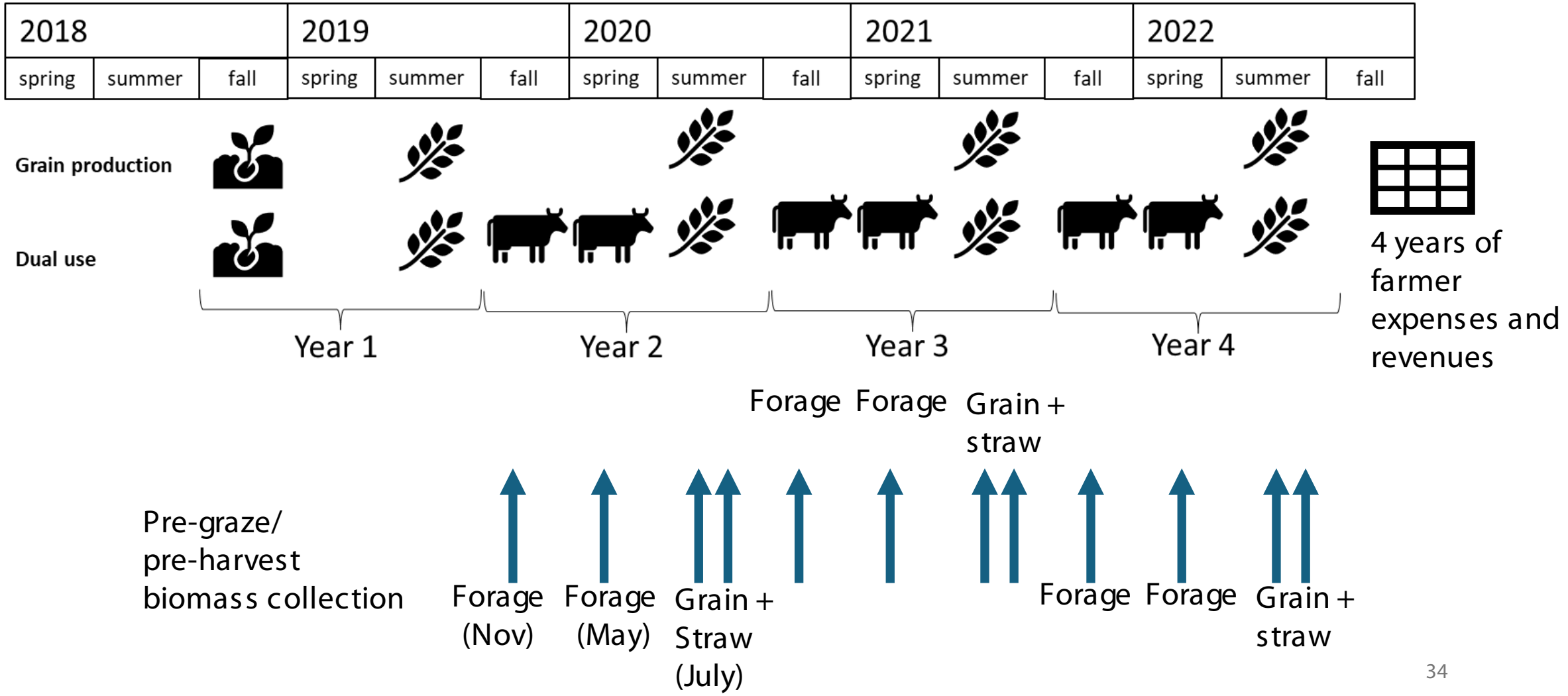
Dual use had highest expenses

Expenses	Grain only	Grain+Straw	Dual Use
	ha-1 yr-1		
Land Cost (rent=$494 ha-1 yr-1)	$494	$494	$494
Seed (12 kg ha-1 @ $24.20 ha-1)	$83	$83	$83
Planting, no-till ($61.75 ha-1)	$18	$18	$18
Fertilizer (37,854 liters liquid dairy manure)	$89	$89	$89
Weed Control	$55	$55	$55
Fencing	$0	$0	$36
Water	$0	$0	$30
Grain Harvest ($136 ha-1)	$117	$117	$117
Grain Handling & Storage ($0.07 kg-1)	$43	$43	$30
Straw Harvest	$0	$144	$144
Grazing Cost, labor	$0	$0	$89
Management cost	$214	$214	$214

Results: Total annual biomass

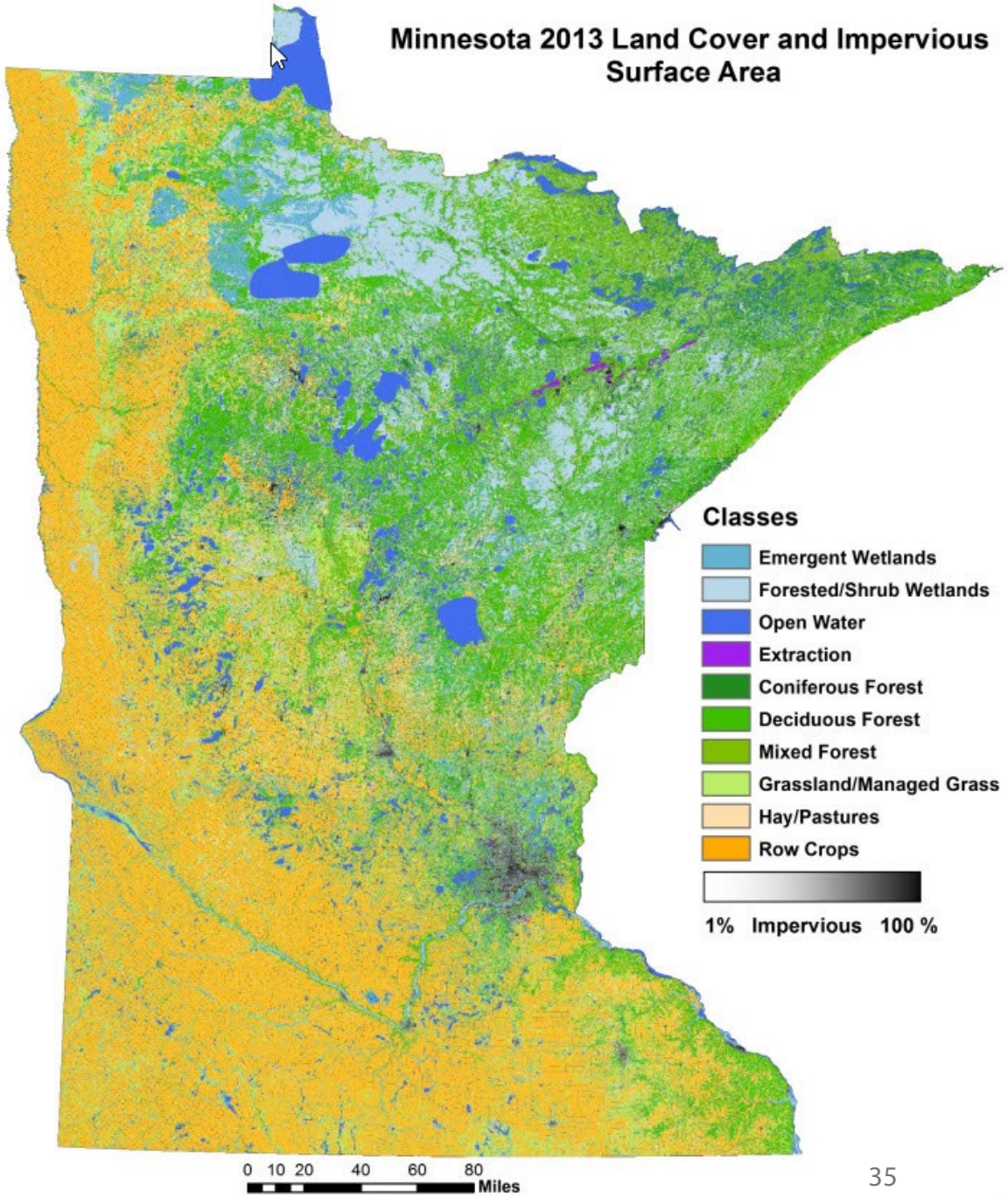


Materials & methods: Data collection



Land use in Minnesota

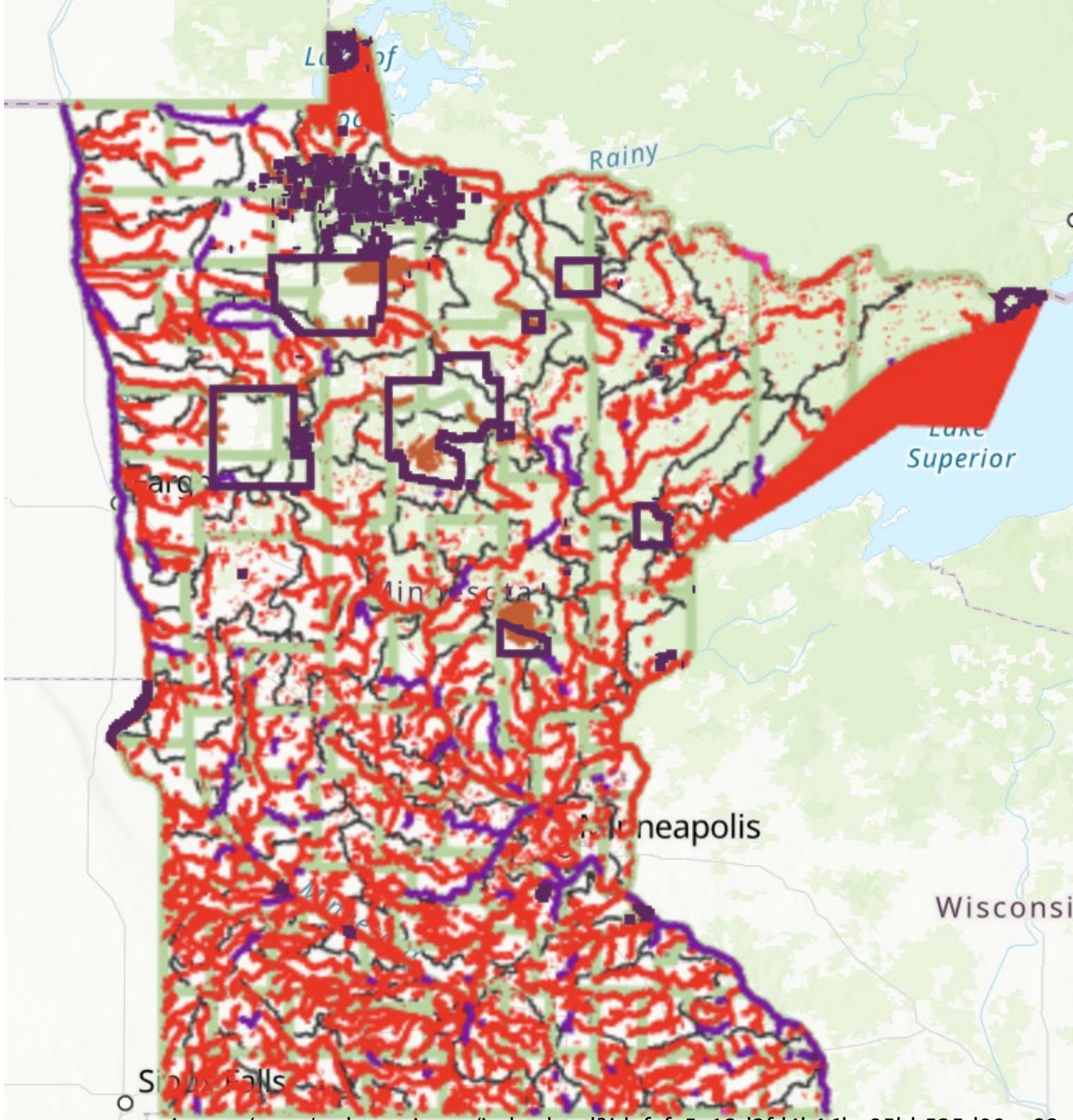
- 51% of total land area is agricultural (MN Board of Water & Soil Resources)
- >99% of all acres planted and harvested are annuals (USDA NASS, 2023)
  - Corn & soybean account for 87% of acres planted
  - 15% more acres planted in corn than in soybean



https://gisdata.mn.gov/dataset/base-landcover-minnesota

The 'Land of 10,000 (impaired) Lakes'

- ~30% of water bodies deemed impaired, with 6,349 impairments (MPCA, 2024)
- Nitrate leaching and phosphorus loading from agricultural activities (Minnesota Nutrient Reduction Strategy, Wall et al., 2014)



https://mpca.maps.arcgis.com/apps/webappviewer/index.html?id=fcfc5a12d2fd4b16bc95bb535d09ae82

Works cited

- Slide 2
  - University of Minnesota. (n.d.). Minnesota Land Cover Classification and Impervious Surface Area by Landsat and Lidar: 2013 update - Version 2. Minnesota Geospatial Commons. https://gisdata.mn.gov/dataset/base-landcover-minnesota
  - Minnesota Board of Water and Soil Resources. Agricultural Land. Agriculture in Minnesota. https://bwsr.state.mn.us/agricultural-lands
- Slide 3
  - Minnesota Pollution Control Agency. (2023, November 14). Minnesota adds impairments in 54 streams and lakes to 2024 impaired waters list, fewest additions in recent years. News and stories. https://www.pca.state.mn.us/news-and-stories/minnesota-adds-impairments-in-54-streams-and-lakes-to-2024-impaired-waters-list-fewest-in-years
  - Wall, et al., 2014. The Minnesota Nutrient Reduction Strategy. Retrieved 6/10/2024. https://www.pca.state.mn.us/sites/default/files/wq-s1-80.pdf

IWG grain cropping system outcomes

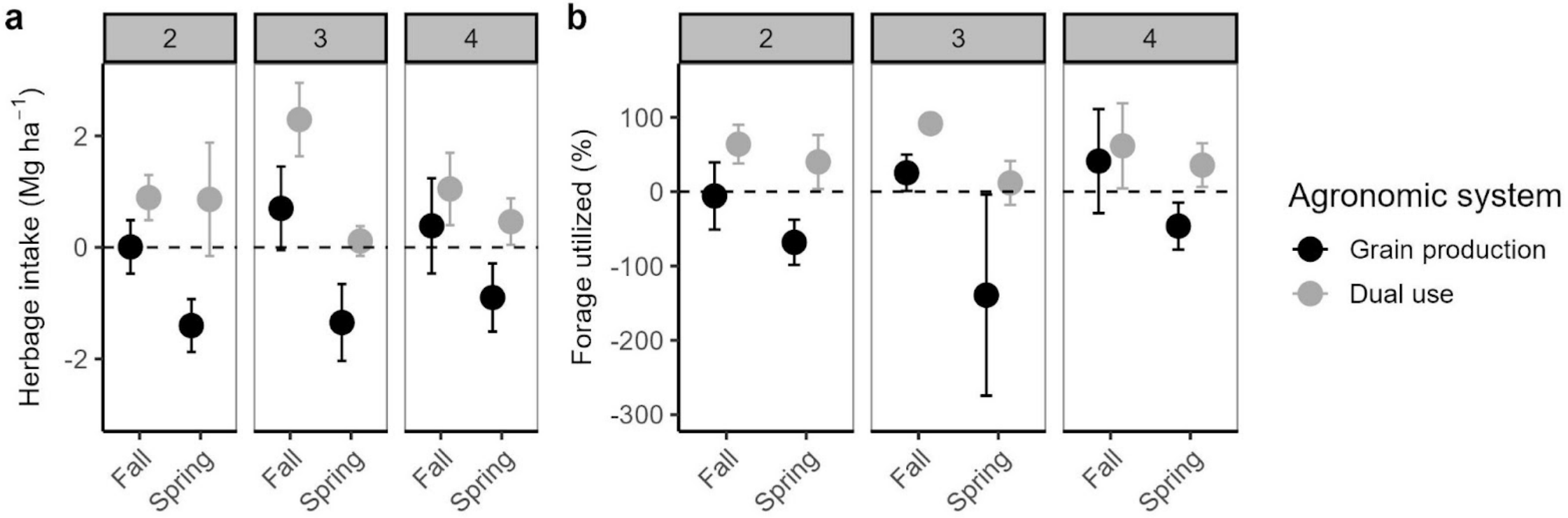
- Fewer inputs than annual crops (Bajgain et al., 2020)
- Prevents soil erosion (Kantar et al., 2016)
- Promotes soil C accrual (van der Pol et al., 2022)
- Reduces nitrate leaching (Jungers et al., 2019)
- Earns price premiums (Lanker et al., 2020)
- Lower yields than wheat (Law et al., 2022)

	2018		2019		2020	
	Annual	IWG	Annual	IWG	Annual	IWG
Soil solution NO_3^--N (mg L^{-1})	19.0a	4.3b	22.1a	0.8b	7.8a	0.3b
Grain yield (Mg ha^{-1})	3.05a	0.85b	7.33a	0.43b	1.98a	0.22b
Biomass yield (Mg ha^{-1})	2.43b	4.12a	5.85	5.41	2.86b	4.41a

Crops in the annual system were soybean, corn and soybean in 2018, 2019, and 2020, respectively. Soil solution NO_3^--N were averaged across depths. Lower-case letters denote statistical significance between treatments at $P < 0.05$ within each year.

Reilly et al., 2022

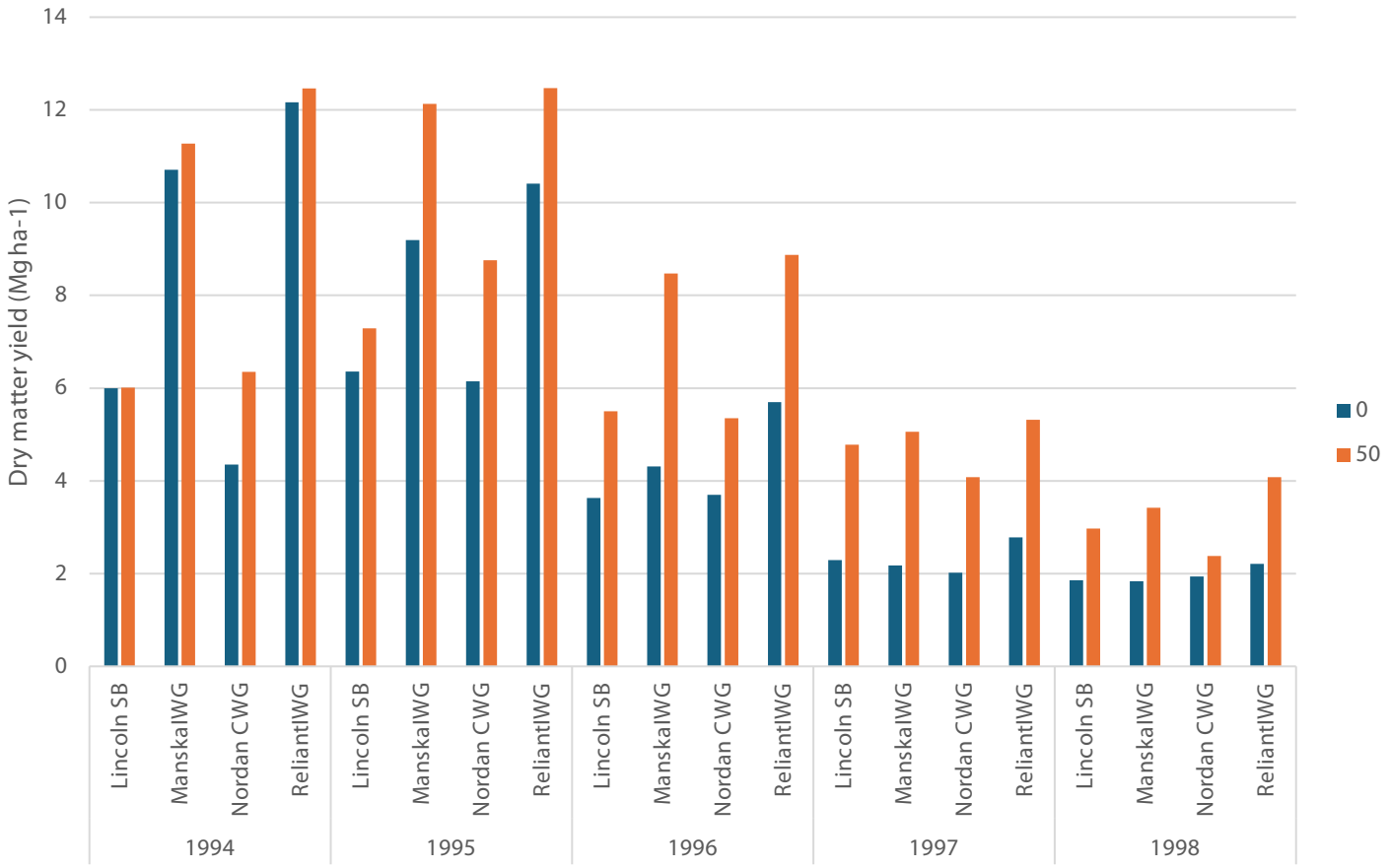
Results: Herbage intake & Forage utilization



Discussion

- Grain earned the highest price but produced the lowest yield, the opposite was true of the straw
- Some discrepancy between experimental grain yields and grain sales
  - Year 4 straw yields
    - Actual: 12,700 lbs valued at $1,400
    - Experimental: No straw data
  - Year 2 grain yields:
    - Actual: 943 kg sold in both GP and DU
    - Experimental: GP grain yield > DU grain yield

IWG forage vs. smooth brome and crested wheat

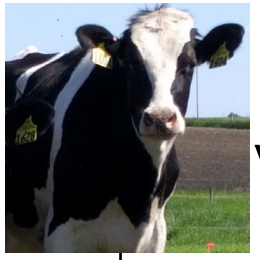


Mitigation strategy: Graze vegetative regrowth for forage

Establishment year

Grazing/forage opportunity

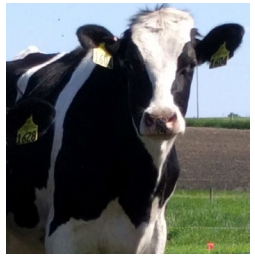
Autumn regrowth



verwintering cover

Grazing/forage opportunity

Spring regrowth



Stem elongation begins

Grain & straw harvest

Grazing/forage opportunity

Autumn regrowth