Farming for Ecosystem Services

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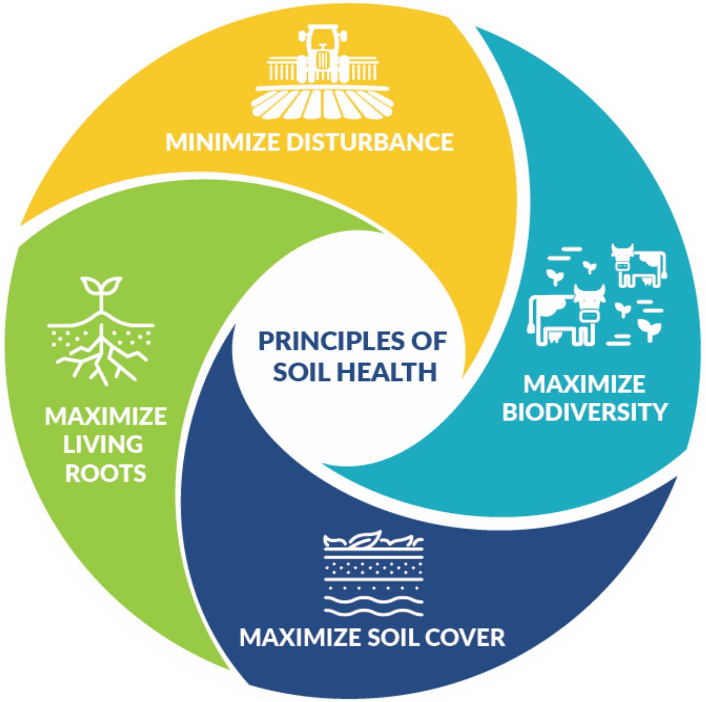
Characteristics Shaping A High-Value Cover Crop

- Low Carbon Intensity
- None to Low Indirect Land Use Change
- Winter Cover Crop
- Build soil health and provides ecosystem services
  - Maximize continuous living roots through double cropping
  - Maximize soil cover for an additional 6 months
  - Minimize soil disturbance through conservation tillage
  - Maximize biodiversity through crop rotation
- Avail ecosystem service markets and state and federal incentives



Ecosystem Services and the Carinata Enterprise

- Improve the value proposition of carinata demonstrating the economic and ecological value as a cash-based off-season winter cover crop
- Increase adoption of carinata as a winter cover crop
- Enhance sustainability of agroecosystems

Why Carinata? Ecosystem Services

Improve soil quality

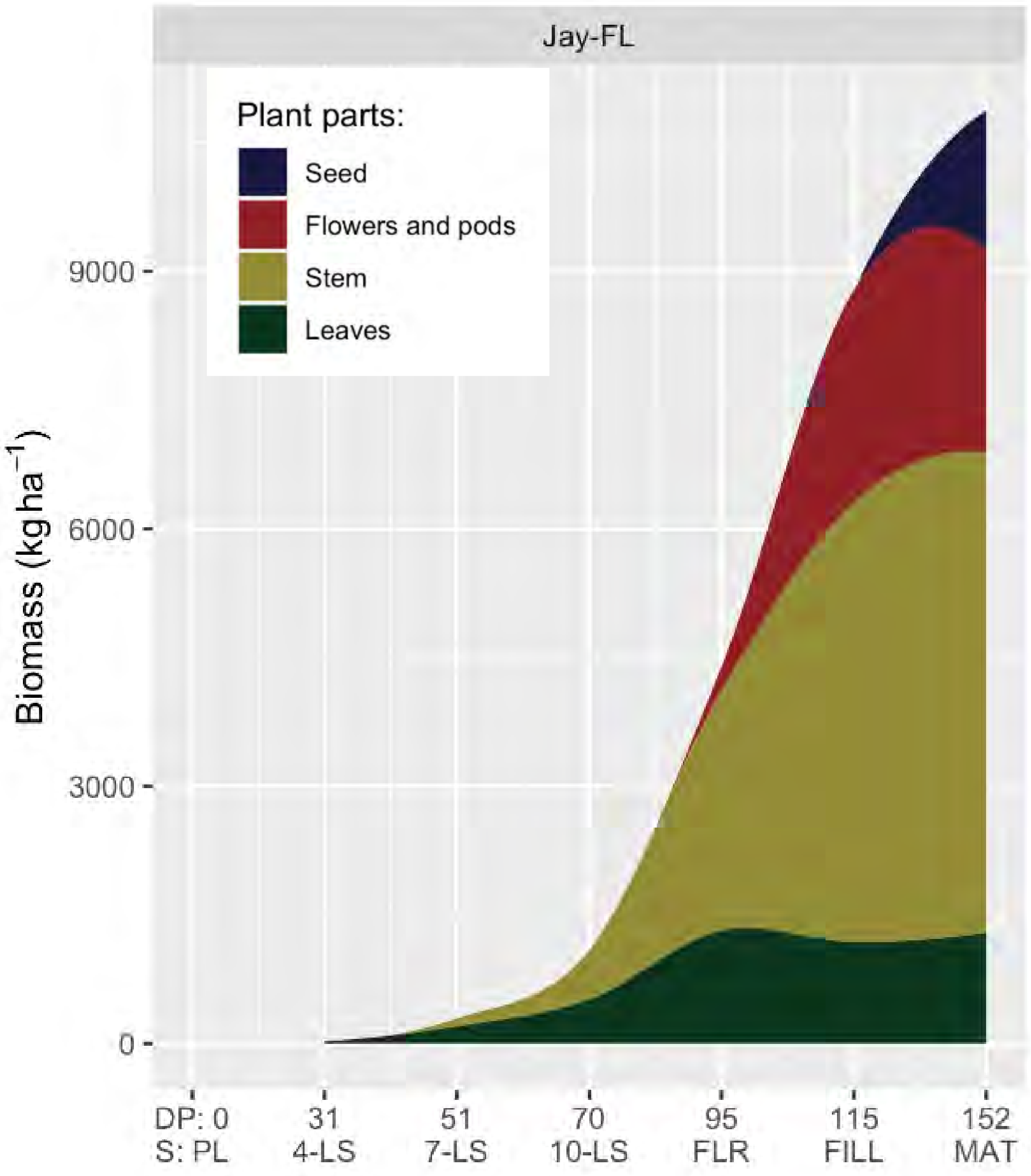
- Increase soil organic matter
- Improve soil structure, quality, tilth
- Reduce soil erosion
- Enhance soil microbial biodiversity
- Reduce soil compaction

Improve soil fertility

- Reduce nutrient leaching
- N, P, K scavenger
- Increase nutrient cycling

Pest reduction

- Suppress weeds
- Reduce nematodes
- More robust crops that follow

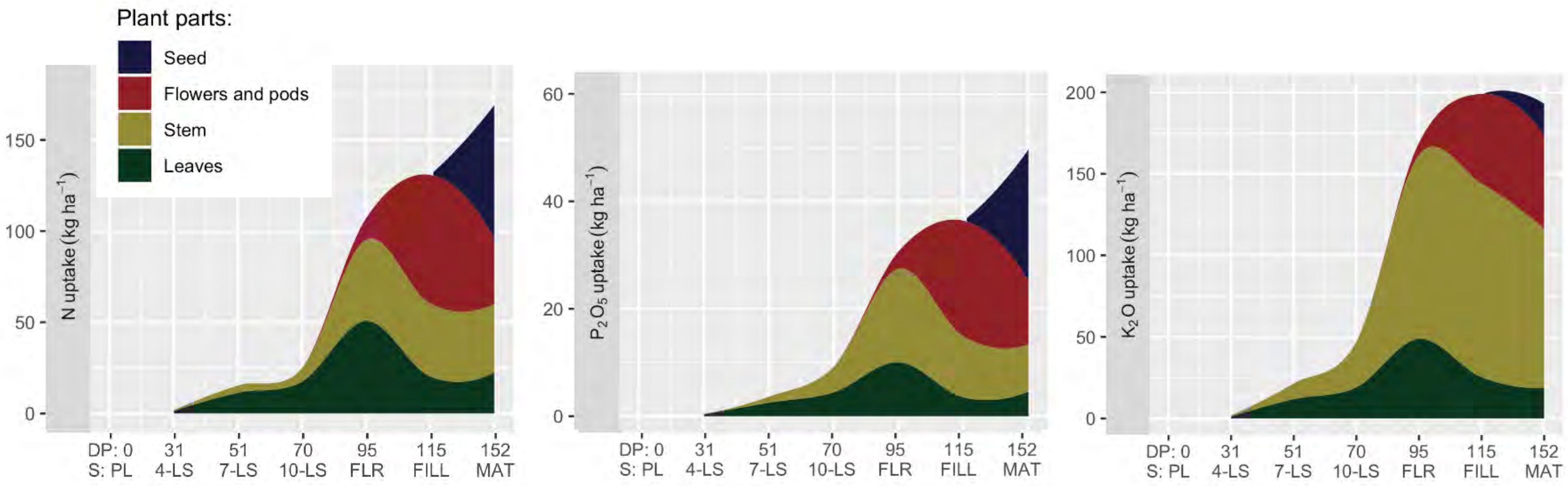


Bashyal et. al, in press

High Residue Cover Crop

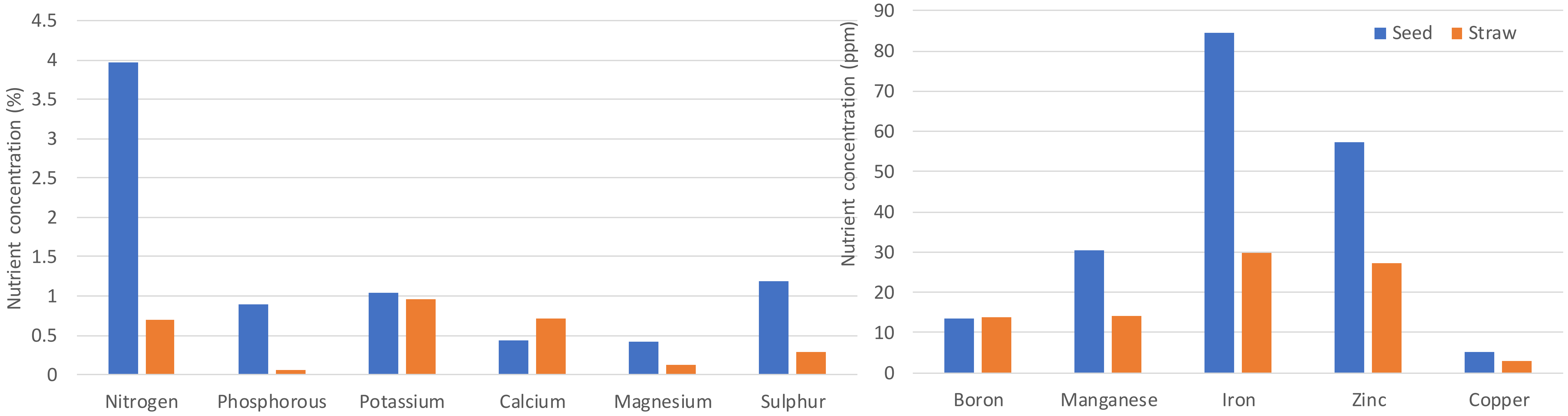
- 180-day crop
- Planted in November and harvested in May
- Accumulating 10,000 kg/ha
- 2500-3000 kg seed/ha harvested
- 7000-7500 kg biomass/ha returned to the soil

Nutrient Cycling

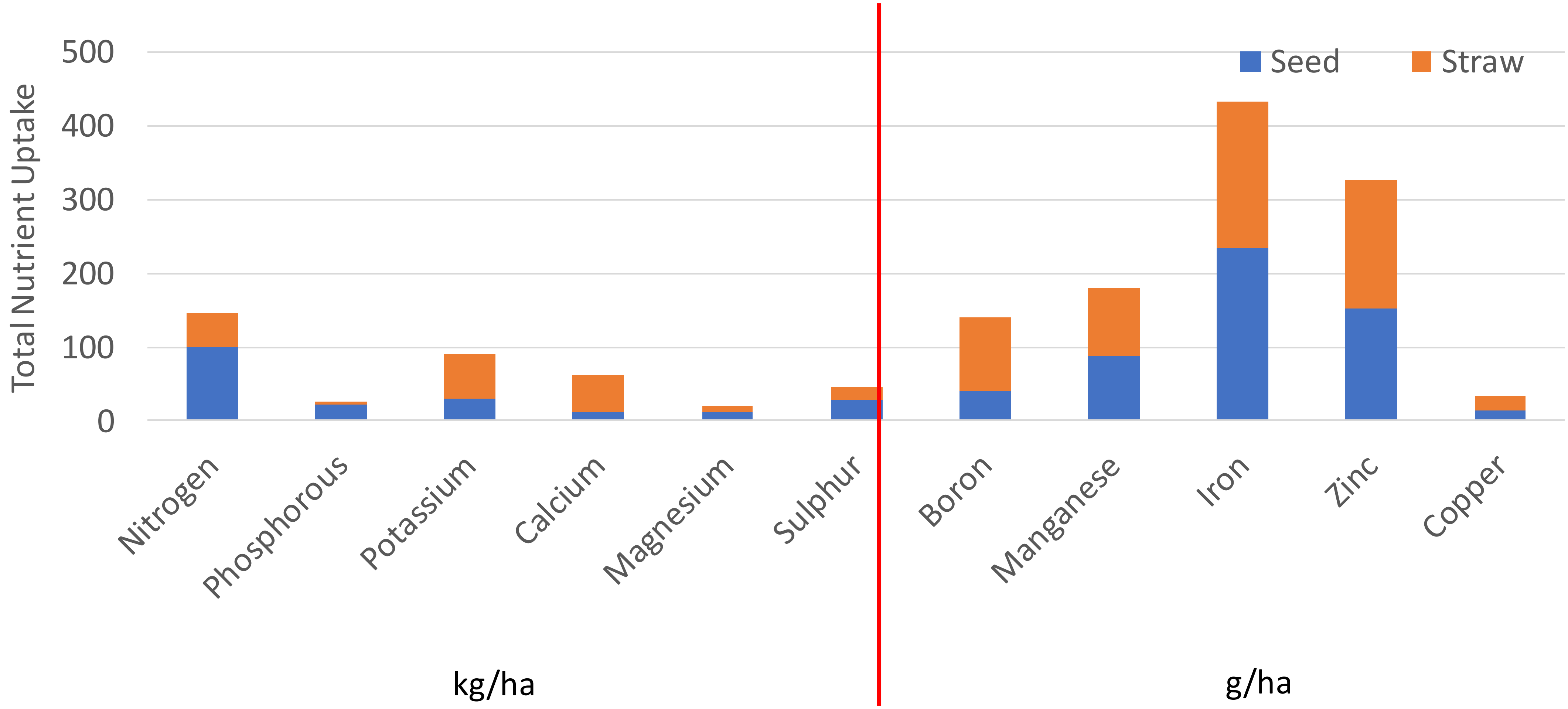


Bashyal et. al, in press

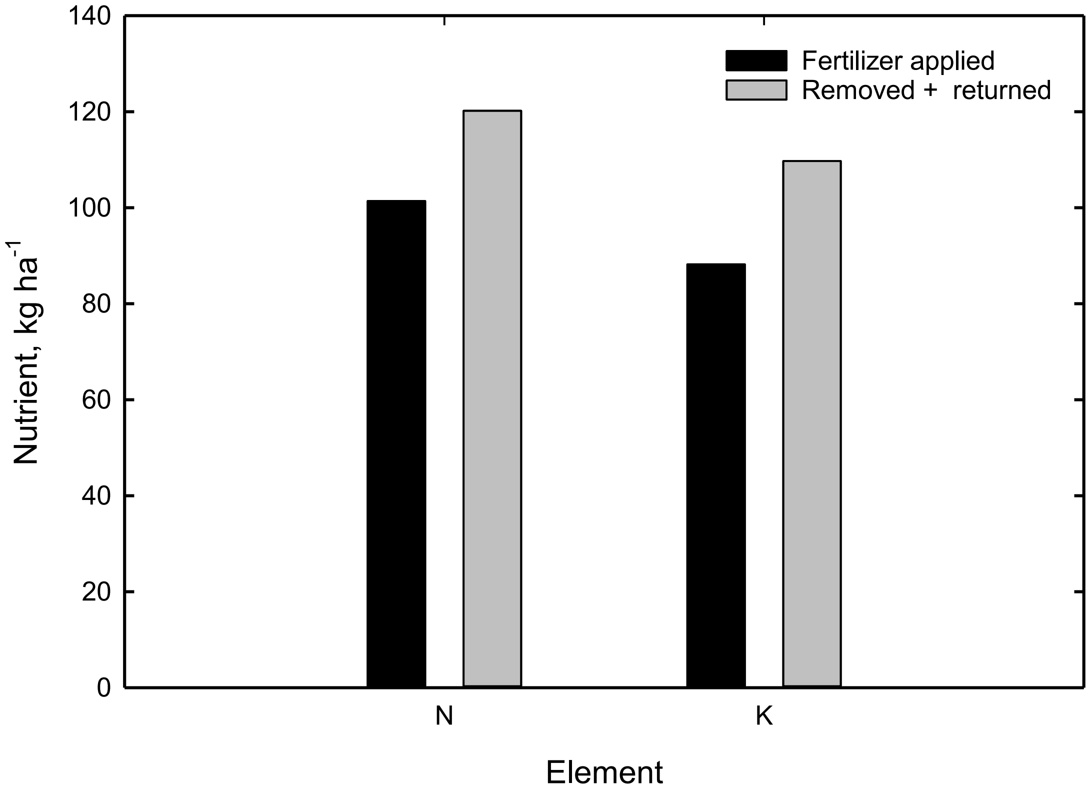
Quality of Biomass



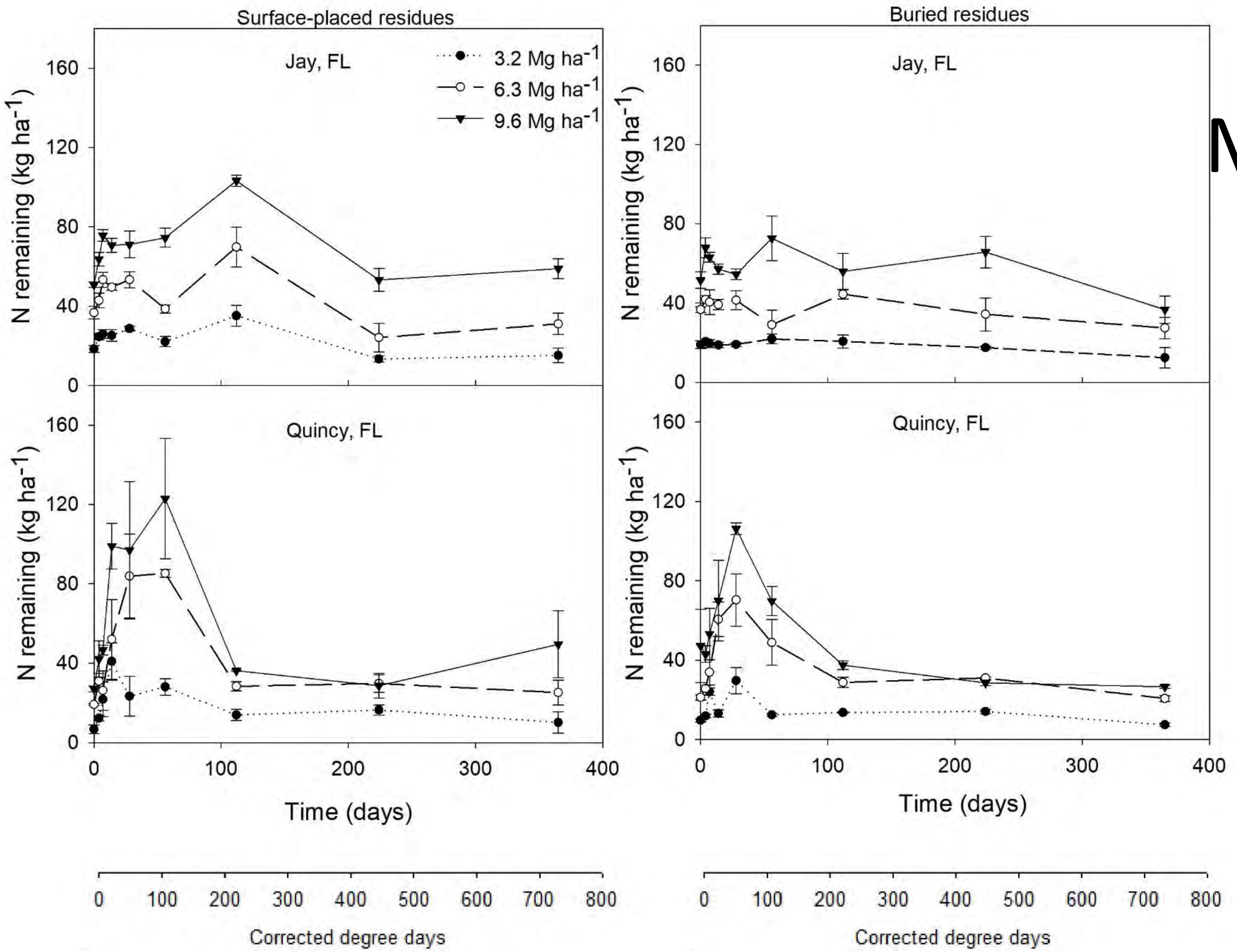
Nutrient Uptake



Nutrient Uptake



- Applied a mean 101 kg N and 88 kg K ha^{-1} over 4 years
- Total N and K uptake were 120 kg N and 110 kg K ha^{-1}
- 82 kg N and 22 kg K ha^{-1} removed in seed
- 39 kg N and 95 kg K ha^{-1} returned in straw

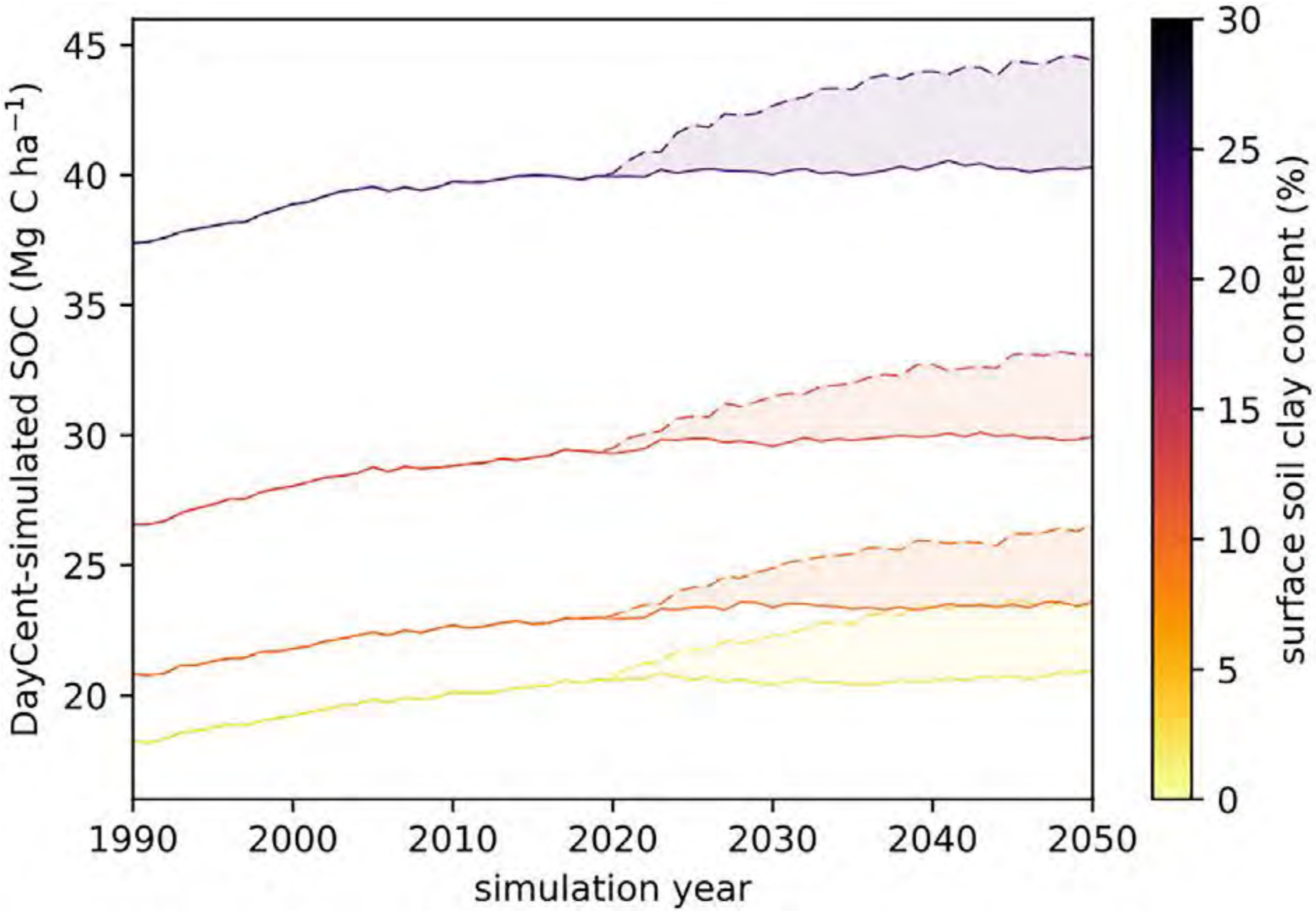


Biomass Mineralization

- Buried residues at Jay mineralized 36% (6.5 kg ha^{-1}), 29% (10.7 kg ha^{-1}) and 29% (14.8 kg ha^{-1}) N at 3200, 6300 and 9600 kg ha^{-1} loading rates, respectively
- 24% (2.4 kg ha^{-1}), 3% (0.64 kg ha^{-1}) and 44% (21.5 kg ha^{-1}) N was mineralized 1 year after placement under the same loading rates in Quincy, FL

Bashyal et. al, in preparation

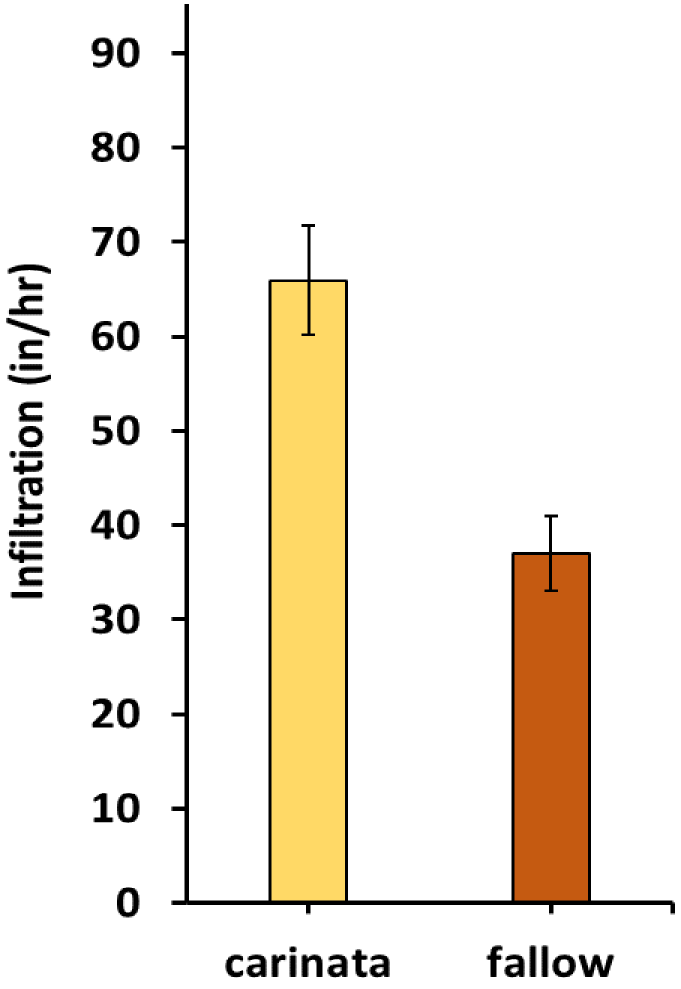
Carbon Sequestration



- Representative soil carbon modeling results for the climate smart no-till establishment scenario, showing four randomly selected simulation strata
- The solid lines show SOC trends under the business-as usual cotton–cotton–peanut reference rotation for each stratum, with the underlying soil texture indicated by color.
- Carinata integration starts in 2020 and results in an increasing SOC trend (dashed lines)

Source: Fields et al, 2022

Water Infiltration Rate



- Infiltration is an indicator of the soil's ability to allow water movement into and through the soil profile
- Restricted infiltration results in poor soil aeration leading to poor root function and plant growth, as well as reduced nutrient availability and cycling by soil organisms
- Non-infiltrated water that runs of a field may increase soil erosion

Source: Joseph Iboyi

Water Quality

- Three future scenarios (S-C: planting stand-alone carinata in winter fallow land every third year, S-W: planting stand-alone winter wheat in winter fallow land every third year, and S-CW: carinata and winter wheat in rotation, one year of winter carinata followed by two years of winter wheat during simulation periods
- The results show that under all three future scenarios, surface runoff, sediment, phosphorus, and nitrogen loadings decrease with higher average monthly reductions in the stand-alone carinata scenario versus the stand-alone winter wheat scenario
- When carinata and winter wheat were planted over 36% of the total watershed area, the reduction in total sediment, mineral phosphorus, and nitrate loads was ranging from 11.5% to 50.0%

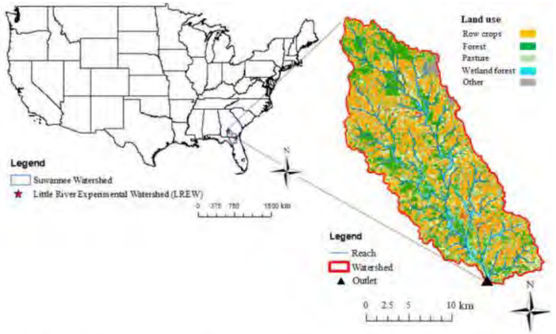
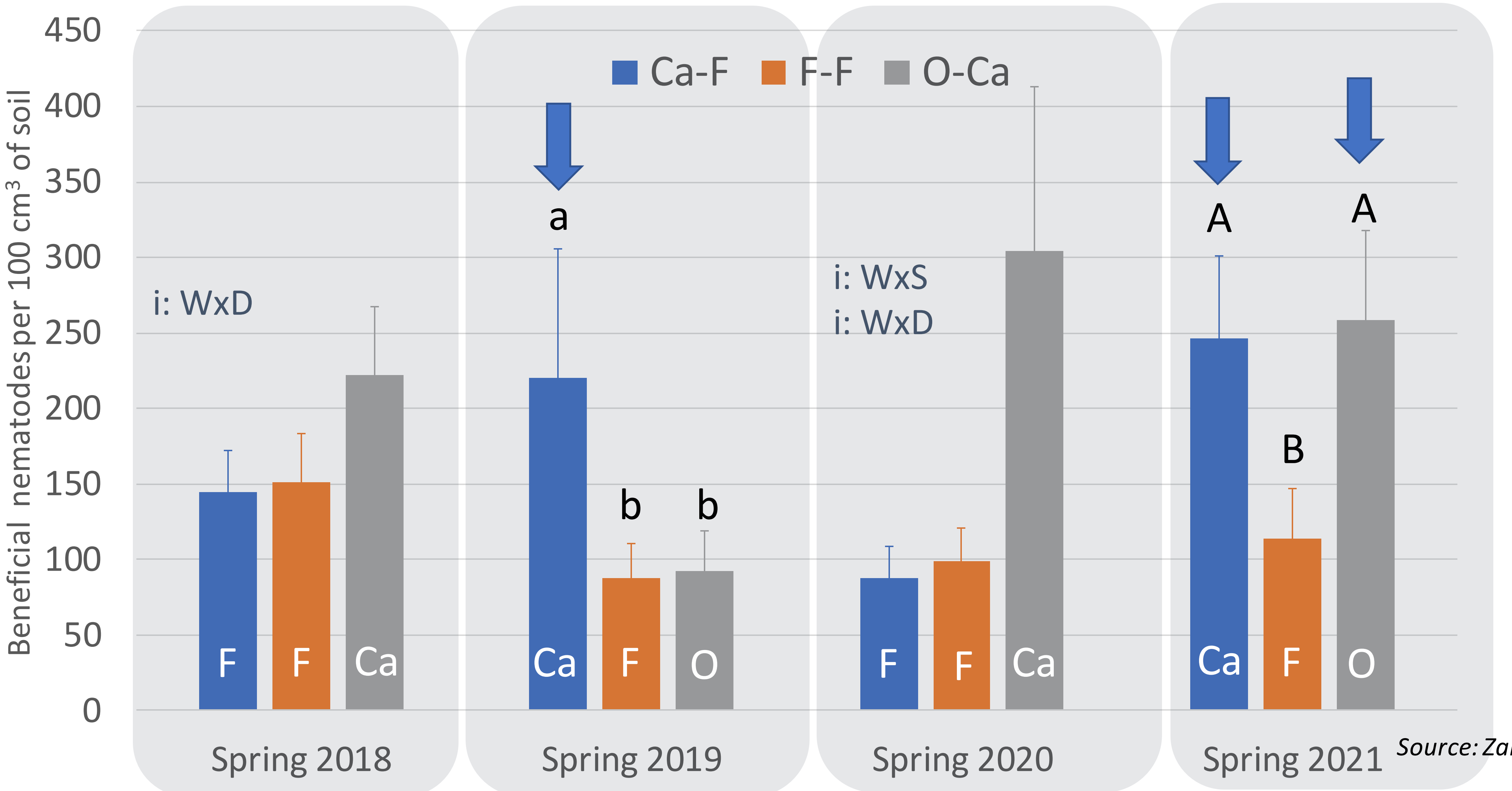


FIGURE 1 Little River Experimental Watershed is located at the headwater of the upper Suwannee River watershed in the Coastal Plain Physiographic Province near Tifton in South-Central Georgia, US. The triangle represents the outlet of the watershed

	Baseline	S-C	S-W	S-CW
Precipitation (mm)	1125.8	1125.8	1125.8	1125.8
ET (mm)	718.1	722.2 (0.6)	719.1 (0.1)	725.2 (0.9)
Surface runoff (mm)	94.9	94.1 (−0.8)	94.6 (−0.3)	93.6 (−1.4)
Percolation (mm)	278.0	274.9 (−1.1)	277.3 (−0.2)	272.5 (−1.9)
Water yield (mm)	408.4	404.3 (−1.0)	407.4 (−0.2)	401.1 (−1.8)
Total sediment (tonne ha^{-1})	2.60	2.50 (−3.8)	2.56 (−1.52)	2.3 (−11.5)
Soluble P (kg P ha^{-1})	0.14	0.12 (−14.3)	0.12 (−14.3)	0.08 (−42.8)
NO_3-N load in surface runoff (kg ha^{-1})	2.6	2.5 (−3.8)	2.5 (−3.8)	1.3 (−50.0)
NO_3-N leaching (kg ha^{-1})	45.3	45.0 (−0.6)	44.9 (−0.8)	27.0 (−40.3)

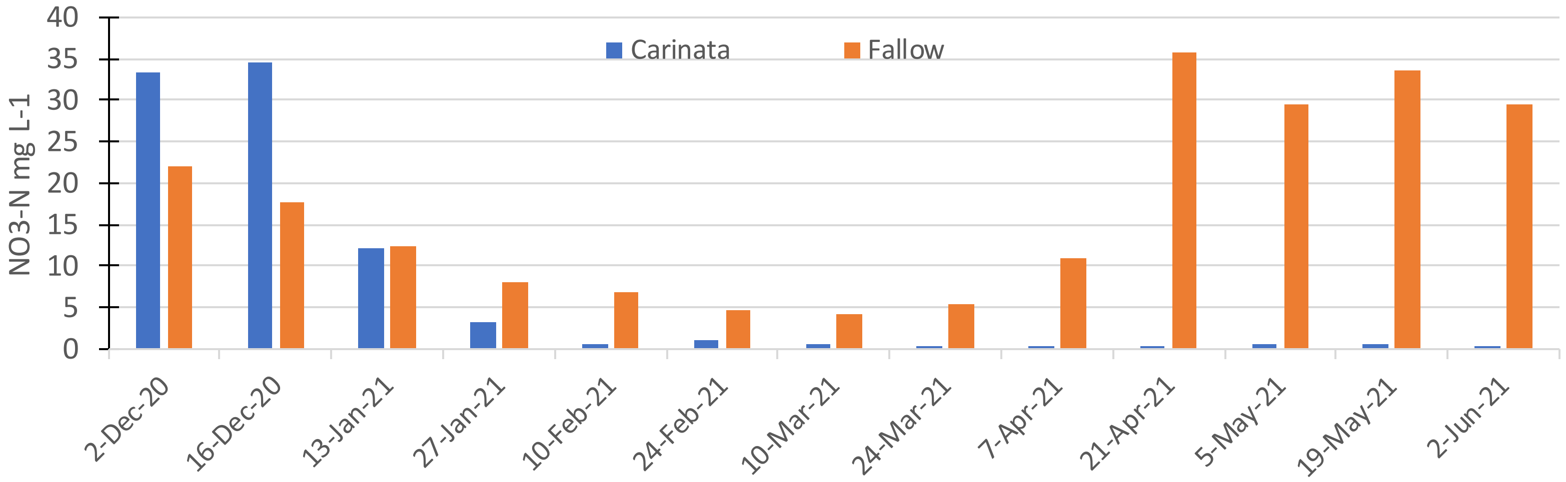
Source: Hoghooghi et al, 2020

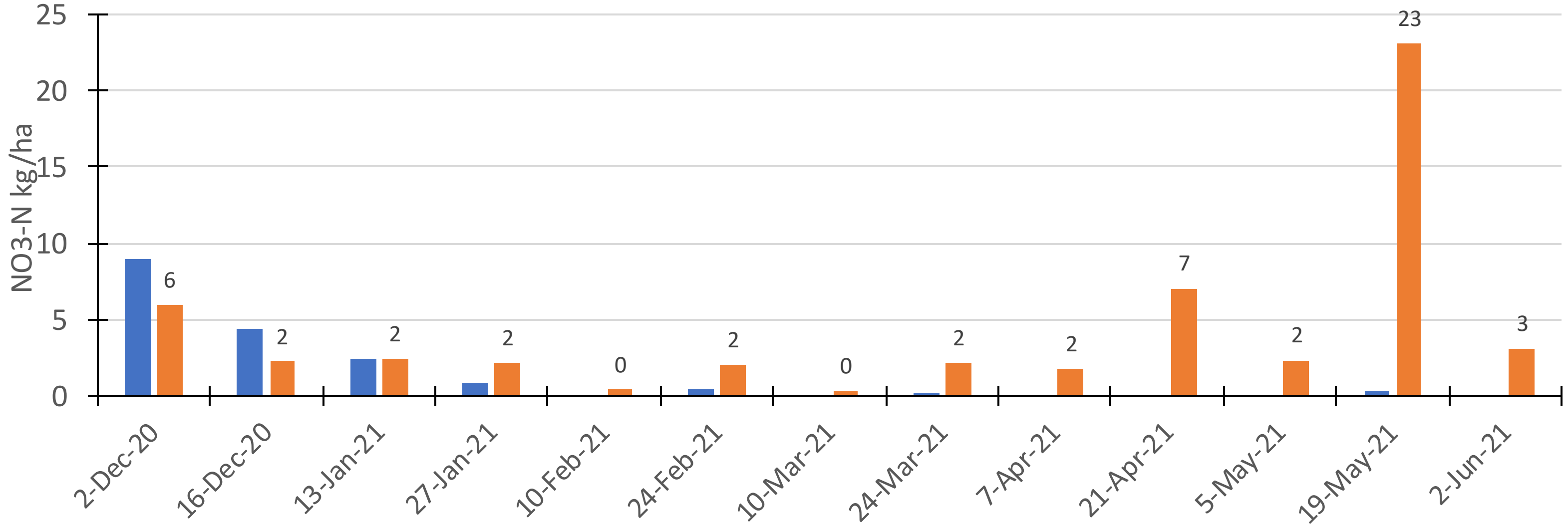
Nematode Management



Source: Zane Grabau

Water Quality





- Seasonal nitrate concentration of leachate 160% greater in the fallowed system.

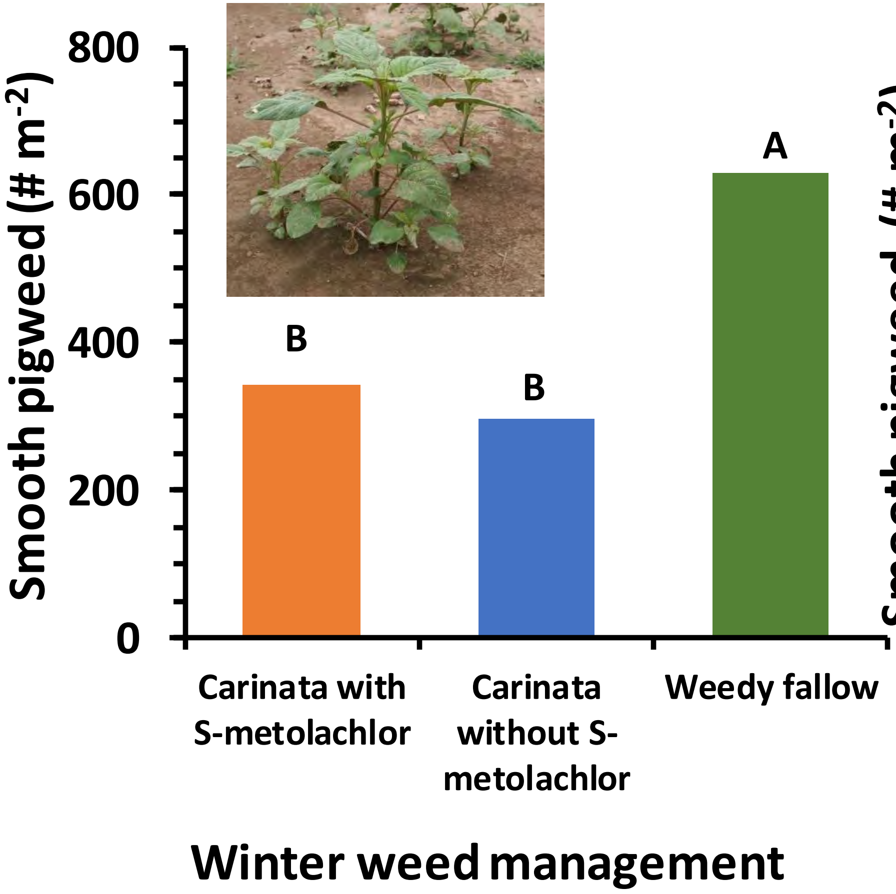
- Seasonal nitrate leached was 231% greater in the fallowed system.

Weed Management

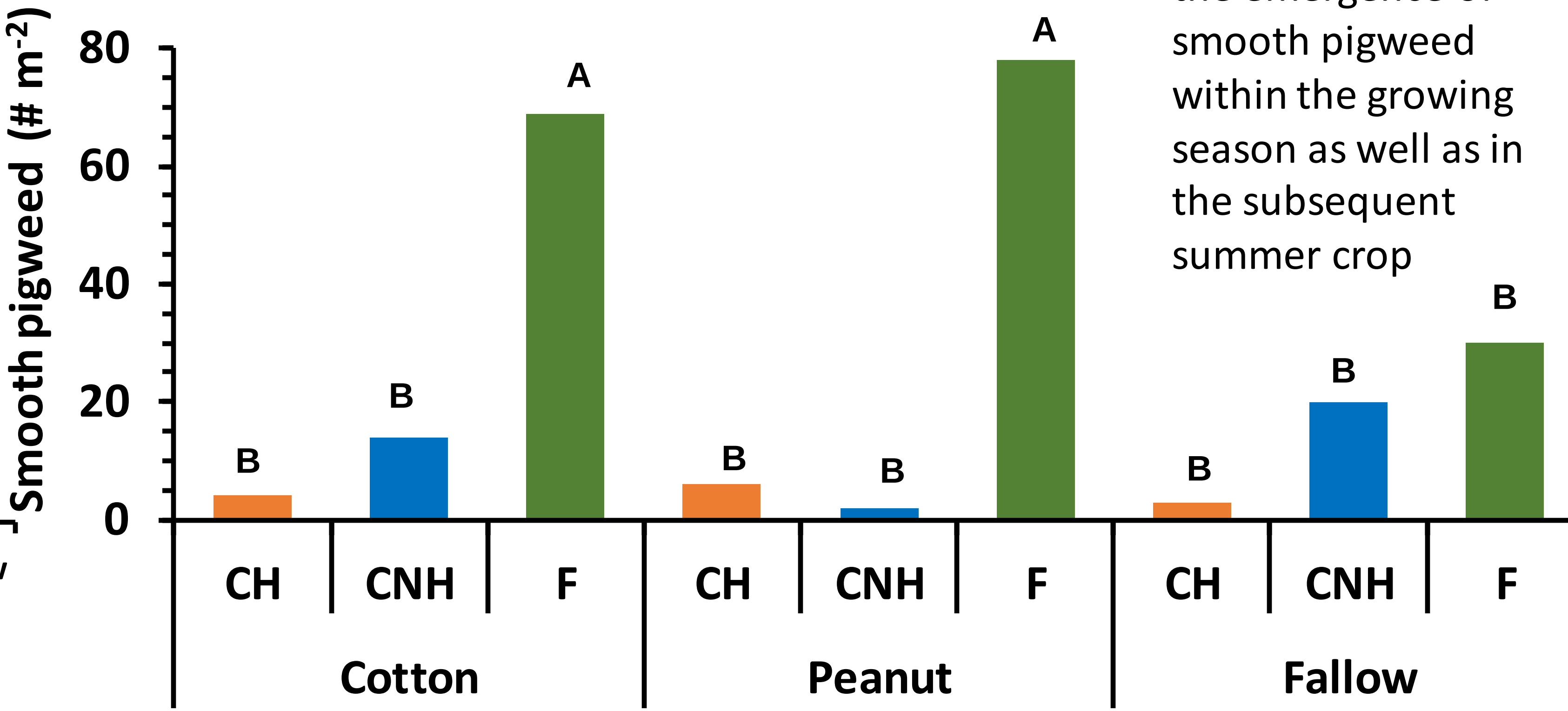
CH = Carinata with *S*-metolachlor
CNH = Carinata without *S*-metolachlor
F = Weedy fallow

Palmer amaranth emergence

Field



Greenhouse



- Carinata reduced the emergence of smooth pigweed within the growing season as well as in the subsequent summer crop

Source: Ruby Tiwari, Pratap Devkota, Ramon Leon

Pollinator Health

- Identified 53 species of carinata pollinators and 78 species of non-pollinators
- Carinata provides ecosystem services by providing crop- associated biodiversity benefits by stabilizing insect community composition
- Carinata supports pollinators with floral resources

Source: Shane Stiles, Charlie Fenster, Henning Nottebrock

Farming for Ecosystem Services

- Maximizing ecosystem services require the adoption of best management practices
- Farmer can avail improvements in soil health – water conservation, carbon sequestration, and greenhouse gas savings to generate ecosystem service credits to sell
- Enabling policies that reward producers for maintained and improved agroecosystems
- Develop a dynamic model to quantify the effect of production practices on air, water, and soil properties
- Integrated valuation of economic and ecological services

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