

Integrating Forage Seed Crops in Cropping Sequences for Profitability and Soil Health: Experience from Western Canada

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Crop diversification as adaptation measure to changing climate

- Between 1901 and 2020, near Breton, AB (Mapfumo et al. 2023):
 - ❖ large annual fluctuations with positive trends in **temperatures ($0.03\text{ }^{\circ}\text{C yr}^{-1}$)**, **growing degree days (1.38 yr^{-1})**, **number of frost-free days (0.24 yr^{-1})**, total annual precipitation (0.79 mm yr^{-1}), **growing season precipitation (0.60 mm yr^{-1})**, and off-season precipitation (0.25 mm yr^{-1}).
- $2\text{ }^{\circ}\text{C}$ rise in temperature throughout western interior Canada since 1950 (DeBeer et al. 2016)
- increase in May to August precipitation by 26% and the frost-free period by 41 days 1901 to 2002 (Shen et al. 2005)
- Peace River region had the largest trends for earlier last-spring-frost dates and an increase in frost-free season across the Canadian Prairies (Cutforth et al. 2004, Newton et al. 2021)
- **may present challenges as well as new opportunities for agricultural diversification**

Issues with intensified annual crops-based cropping systems under changing climate

- **Increasing pest pressure under wheat-canola:**
 - **Clubroot, blackleg, root maggot in Canola** (Harker et al., 2015; Strelkov et al., 2021)
 - ***Fusarium* head blight in wheat** (Chin et al. 2023)
 - **18 weed species in AB are resistant to multiple sites of herbicidal action** (weedscience.org/Pages/Country.aspx)
- **Yield & profitability decline compared to diverse crop rotations:**
 - **>20% yield reduction compared to diverse rotations** (Gill 2018; Harker et al., 2015)
 - **Continuous cropping of canola and pea had less profitability than multiple crops sequences** (Smith et al. 2013)

Search for solutions

- Numerous studies have shown crop diversification as sustainable solutions to agro-ecological issues
- Studies are still lacking on the elucidation of agro-ecological & economic merits of diverse crop rotations

Research questions

- ▶ Can forage seed crops be **profitably** integrated in the annual cropping systems?
- ▶ Can forage seed crops improve **soil health**?

A long-term cropping sequence study (2013-2020)

- Split-plot field experiment
- **Main plots:** 8 cropping sequences

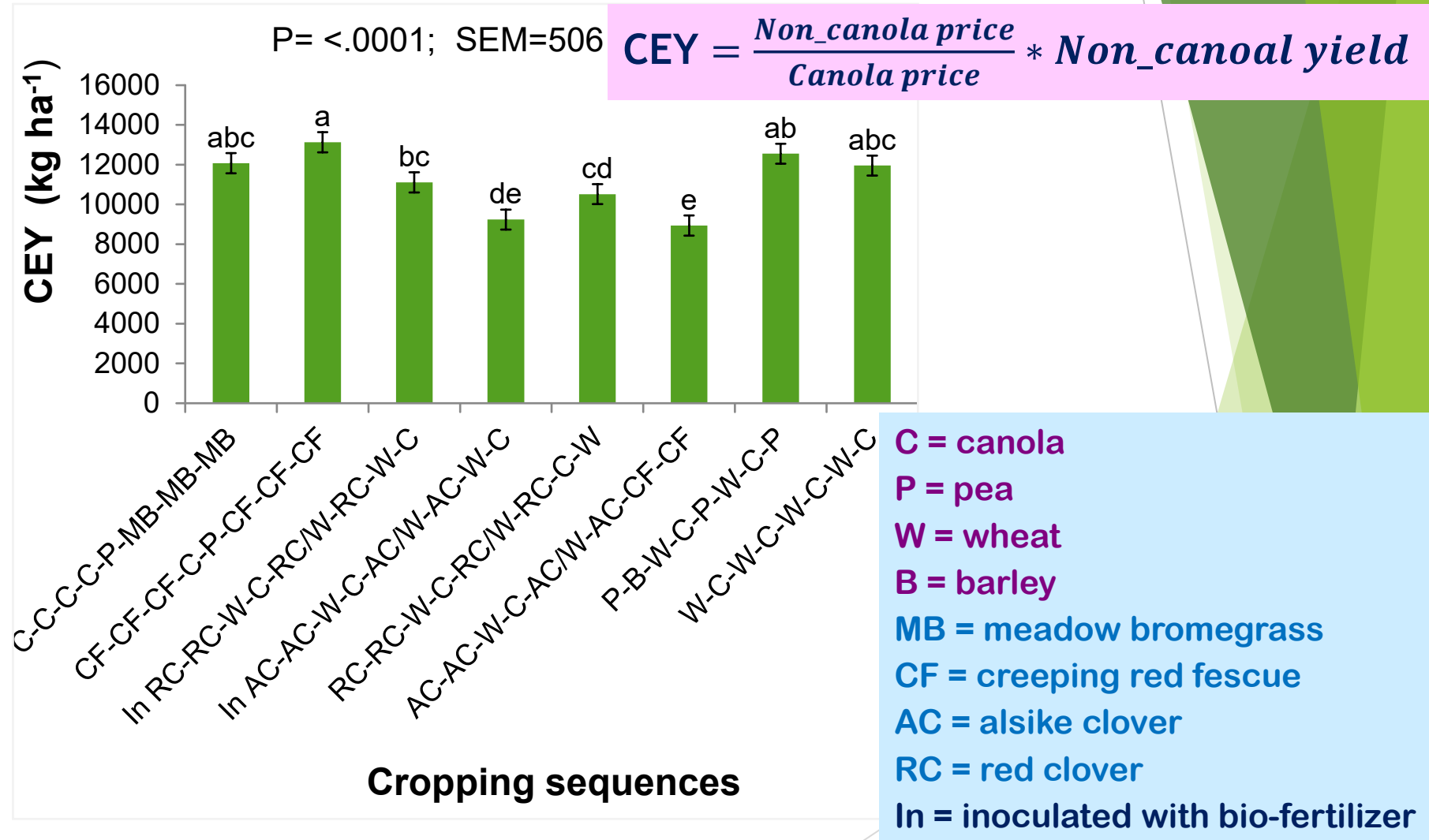
C-C-C-C-P-MB-MB-MB
CF-CF-CF-C-P-CF-CF-CF
In RC-RC-W-C-RC/W-RC-W-C
In AC-AC-W-C-AC/W-AC-W-C
RC-RC-W-C-RC/W-RC-C-W
AC-AC-W-C-AC/W-AC-CF-CF
P-B-W-C-P-W-C-P
W-C-W-C-W-C-W-C

C = canola
P = pea
W = wheat
B = Barley
MB = meadow brome
CF = creeping red fescue
AC = alsike clover
RC = red clover
In = inoculated with bio-fertilizer

- **Sub plots:** 3 levels of N
 - 0, 45 & 90 kg N ha⁻¹

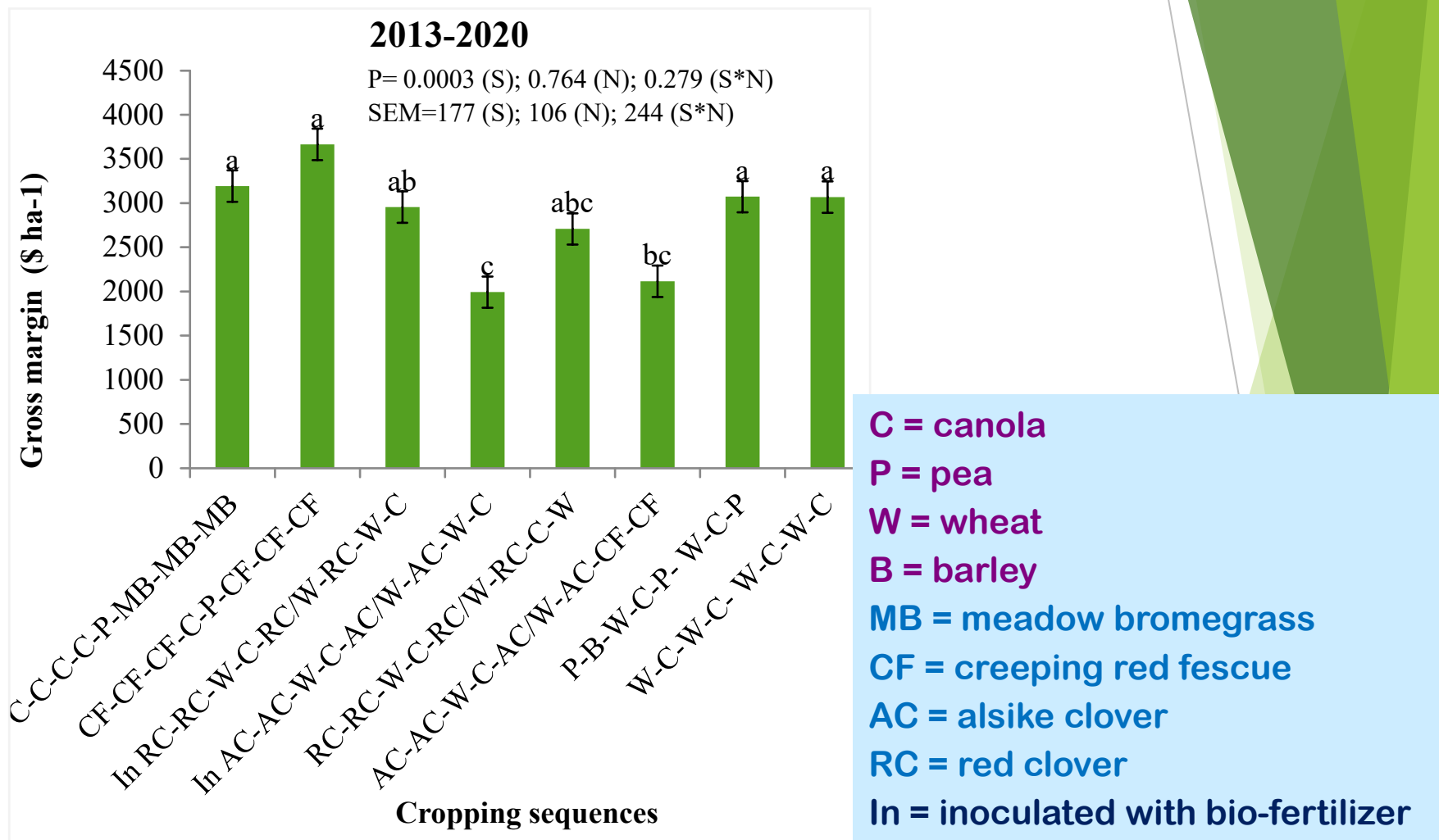
Results

8-year crop sequences: Canola equivalent yield (CEY)



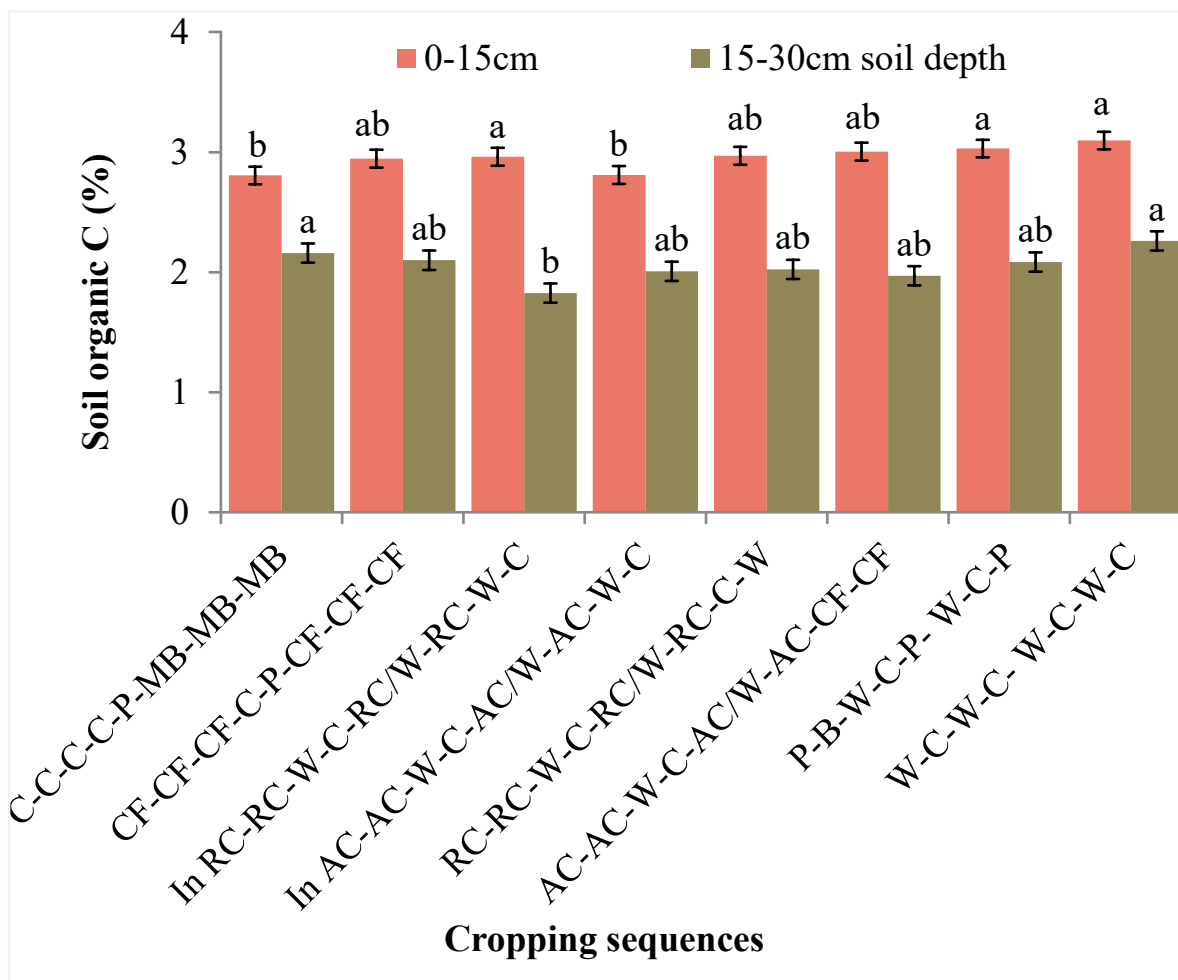
8-year crop sequences: Gross Margins

Gross margin = Gross revenue – partial variable costs



Soil health indicators under different cropping sequences

Soil organic C after 8 sequential crops



C = canola

P = pea

B = barley

W = wheat

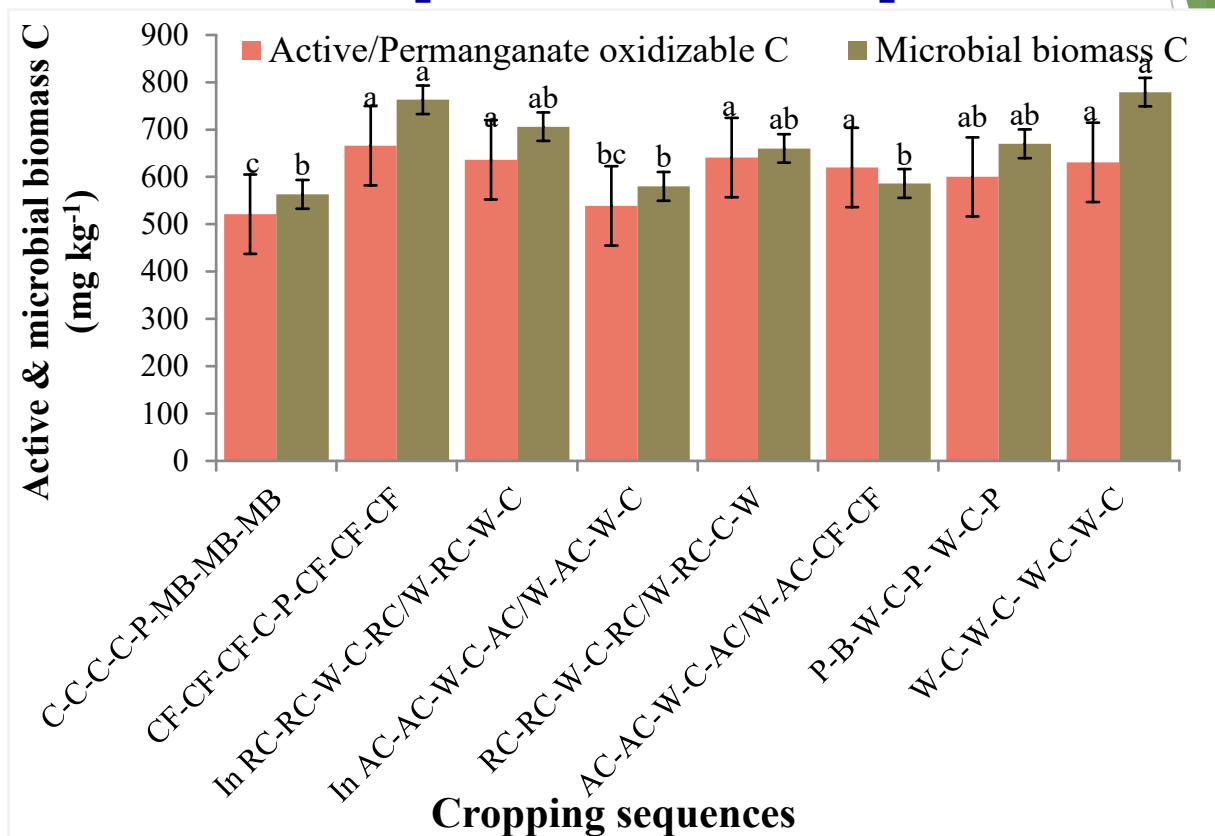
RC = red clover

AC = alsike clover

CF = creeping red fescue

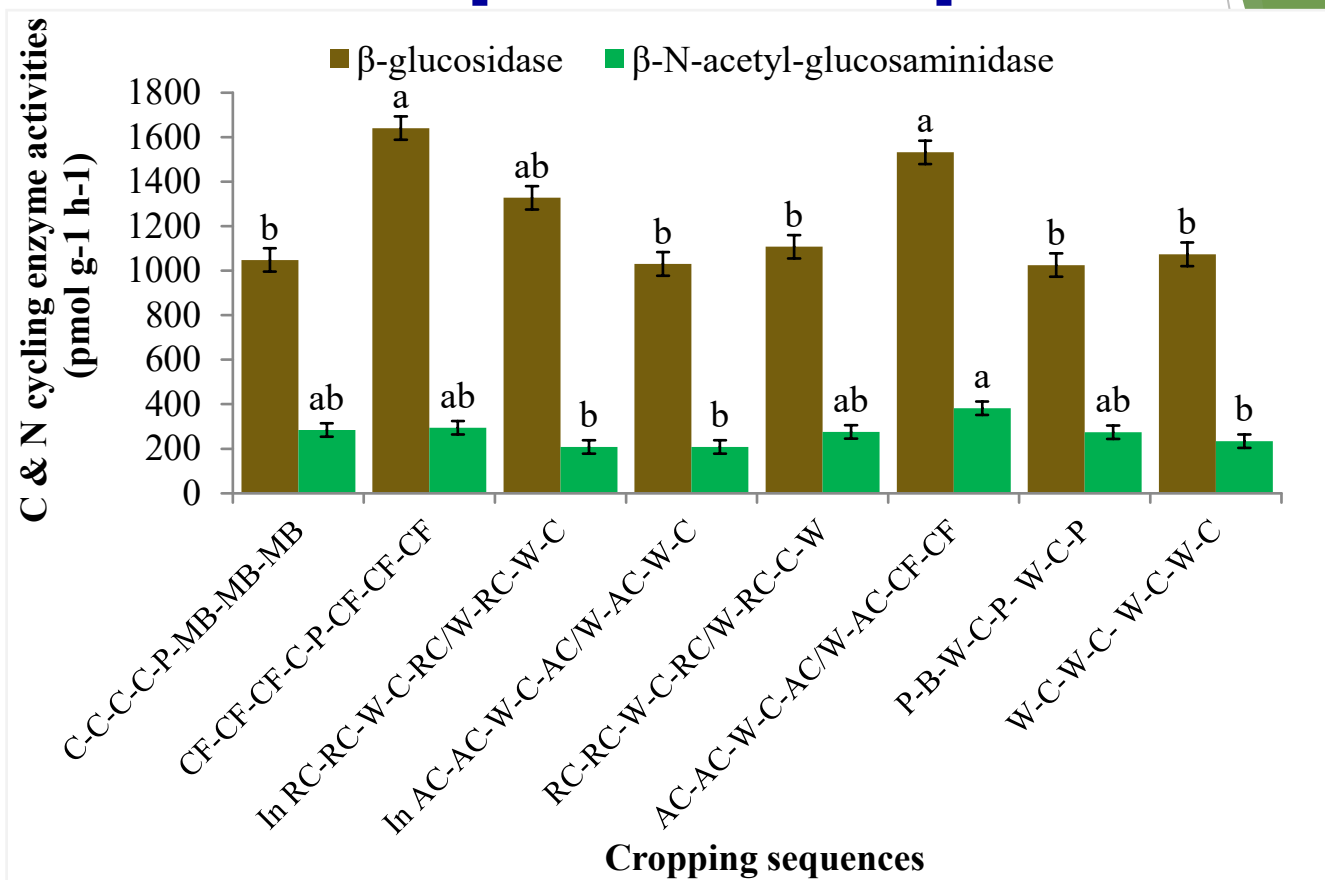
In = inoculated with bio-fertilizer

Soil Active C & microbial C after 8 sequential crops



C = canola **RC = red clover**
P = pea **AC = alsike clover**
B = barley **CF = creeping red fescue**
W = wheat **In = inoculated with bio-fertilizer**

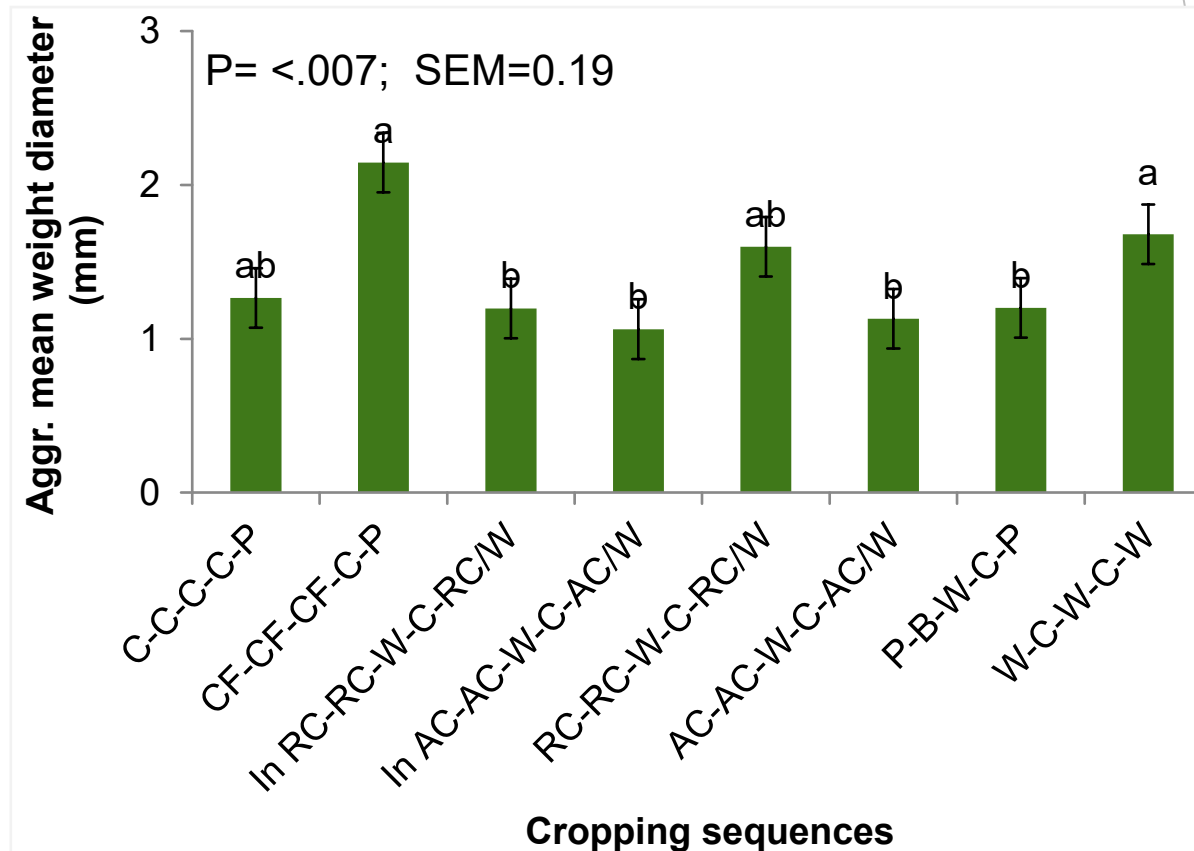
C & N cycling enzyme activities after 8 sequential crops



C = canola
P = pea
B = barley
W = wheat

RC = red clover
AC = alsike clover
CF = creeping red fescue
In = inoculated with bio-fertilizer

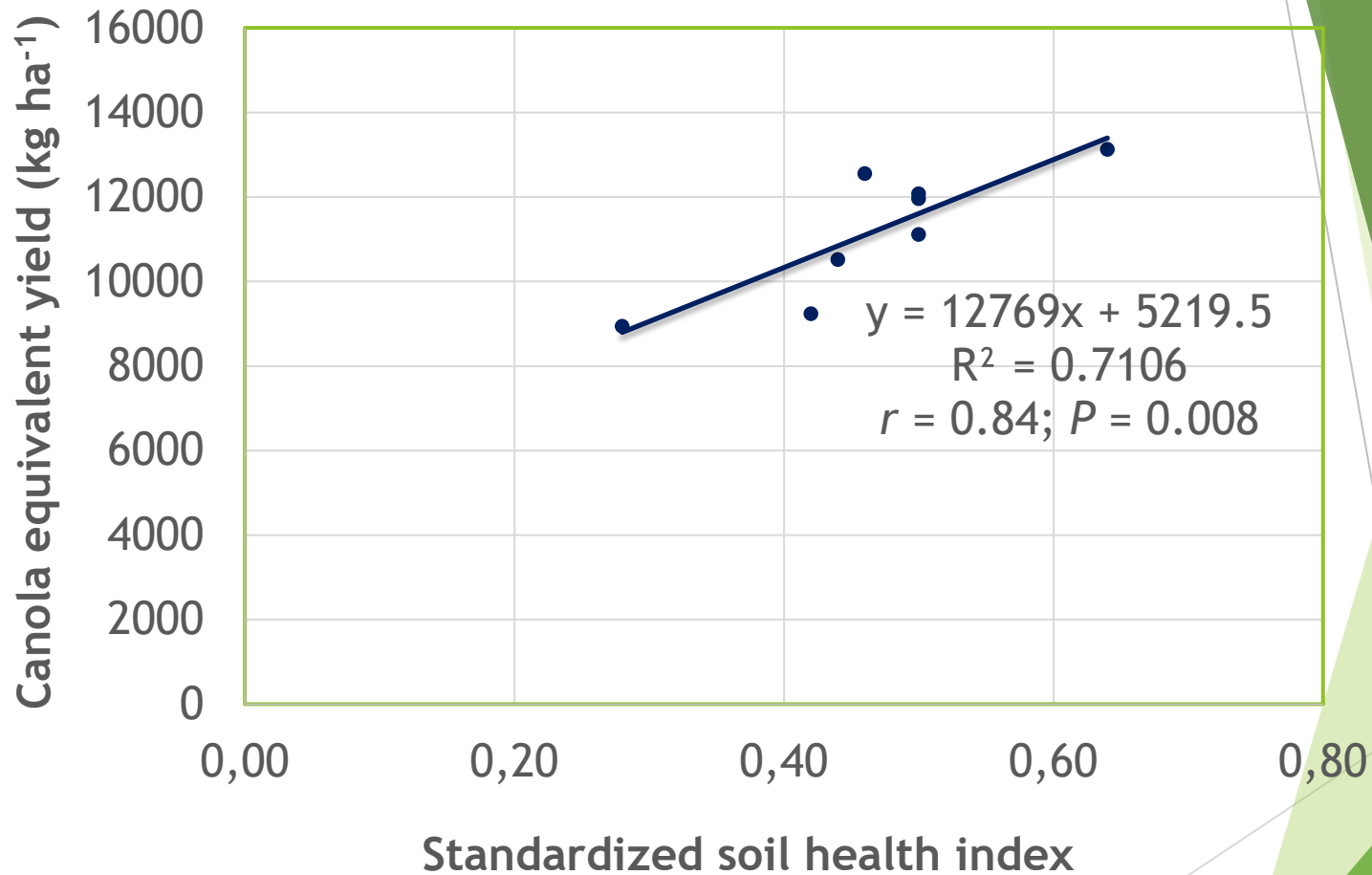
Soil aggregate mean weight diameters in the top 0-15 cm layer, after first five crops in different crop sequences



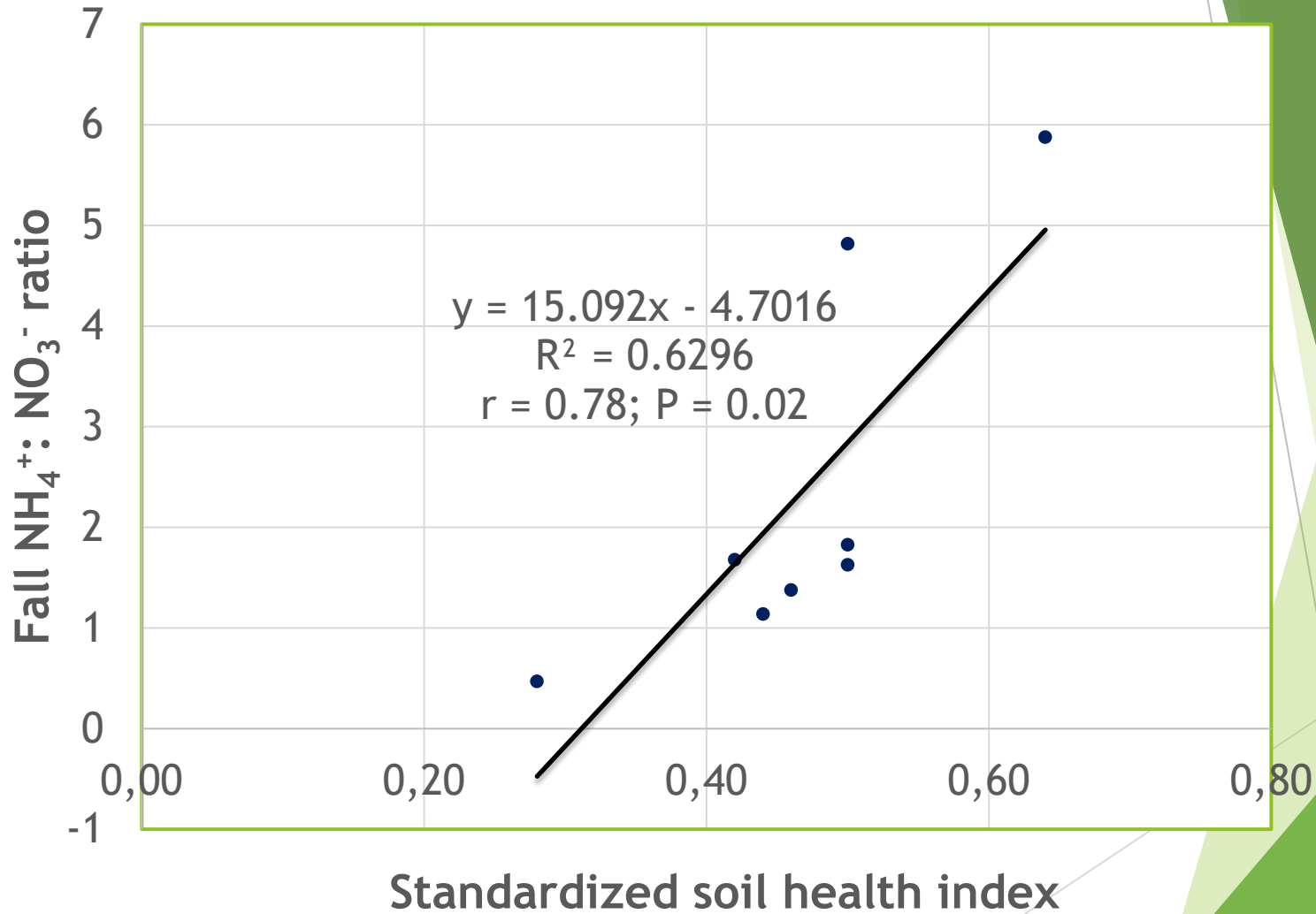
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Soil health & profitability are correlated



Soil health & Fall $\text{NH}_4^+:\text{NO}_3^-$ ratio are correlated



Conclusions

- ▶ Forage seed crops can serve as profitable break crops in the annual cropping sequences with beneficial effects on soil properties
- ▶ Subtle changes in soil health properties between different cropping sequences were detected
- ▶ Close transition between different perennial crops impaired effective termination of preceding perennial & establishment of succeeding perennial crop; e.g., clover followed by creeping red fescue in this study
- ▶ Alternation between annual & perennial crops in cropping sequences allows effective phase transitions
- ▶ Further studies are needed for comparative assessment of nutrients use efficiencies and & environmental health of different cropping sequences

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Thank you !



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