Forage Yield and Quality, Cattle Grazing Capacity, Cost of Production and Soil Carbon in an Annual Polycrop Mixture versus Barley Swath Grazing

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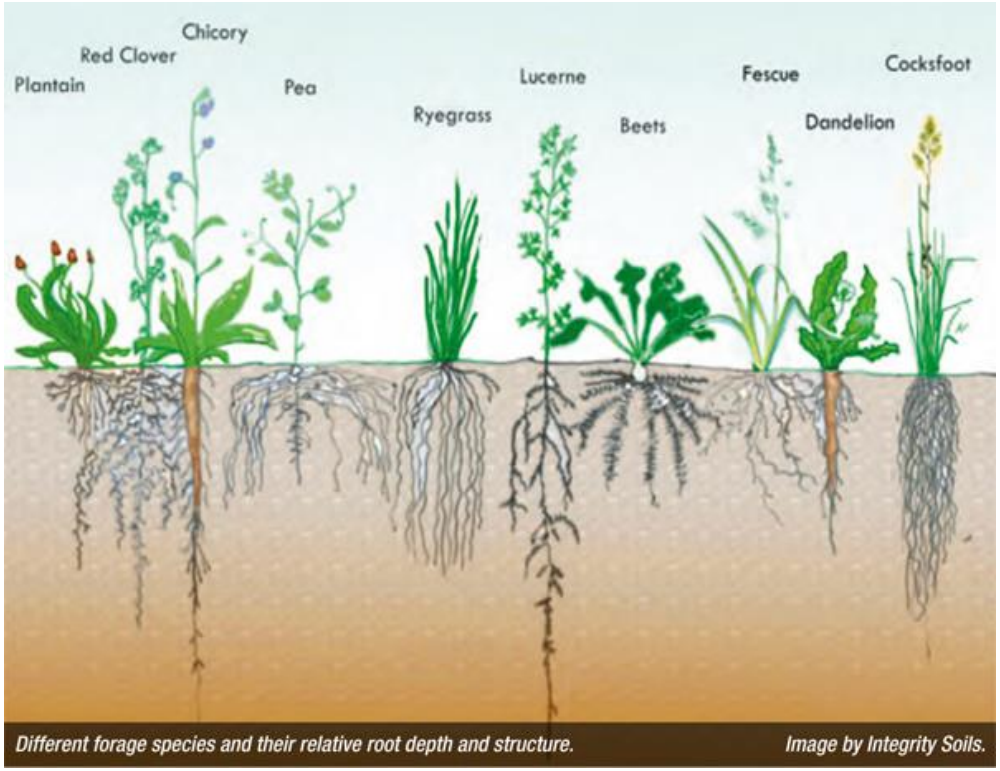
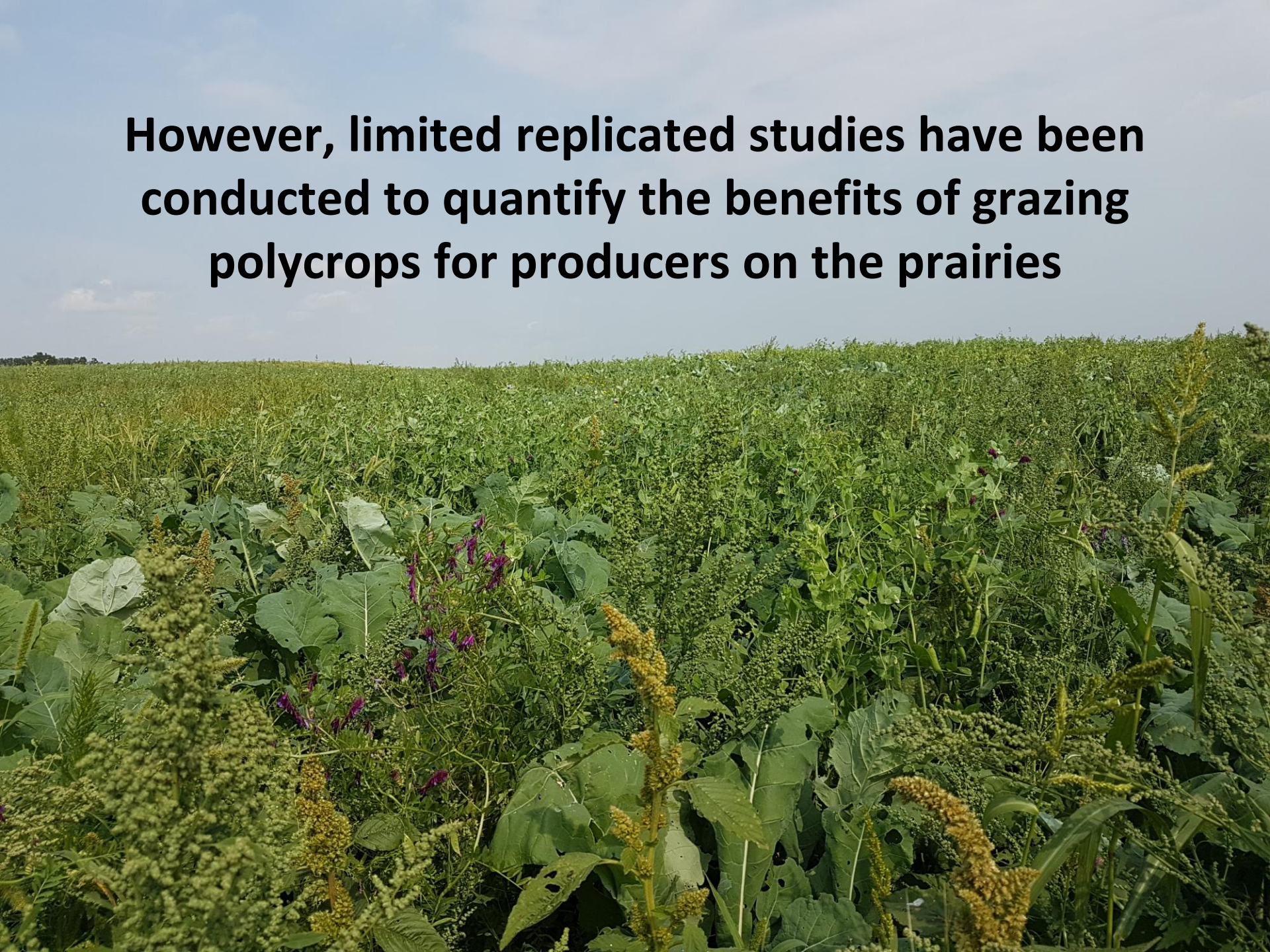
Annual Polycrop Mixtures

- In SK, ~47% of cattle production costs are directly from grazing and winter feeding (Larson, 2013)
- Extensive fall and winter feeding systems can improve cattle production efficiencies (McCartney et al., 2004; McCartney et al., 2008)
- Polycrops (mixed species) have potential to be used in extensive fall and winter livestock feeding systems

Annual Polycrop Mixtures

- Increased total plant performance can arise from the diversity of species competing for resources in different ways (Crawford and Rudgers, 2012)
- Soil organic matter plays a role in:
  a) soil quality, biomass yield, and water quality (Lal, 2004)
  b) nutrient turnover and maintaining soil structure (Banwart et al., 2014)




However, limited replicated studies have been conducted to quantify the benefits of grazing polycrops for producers on the prairies

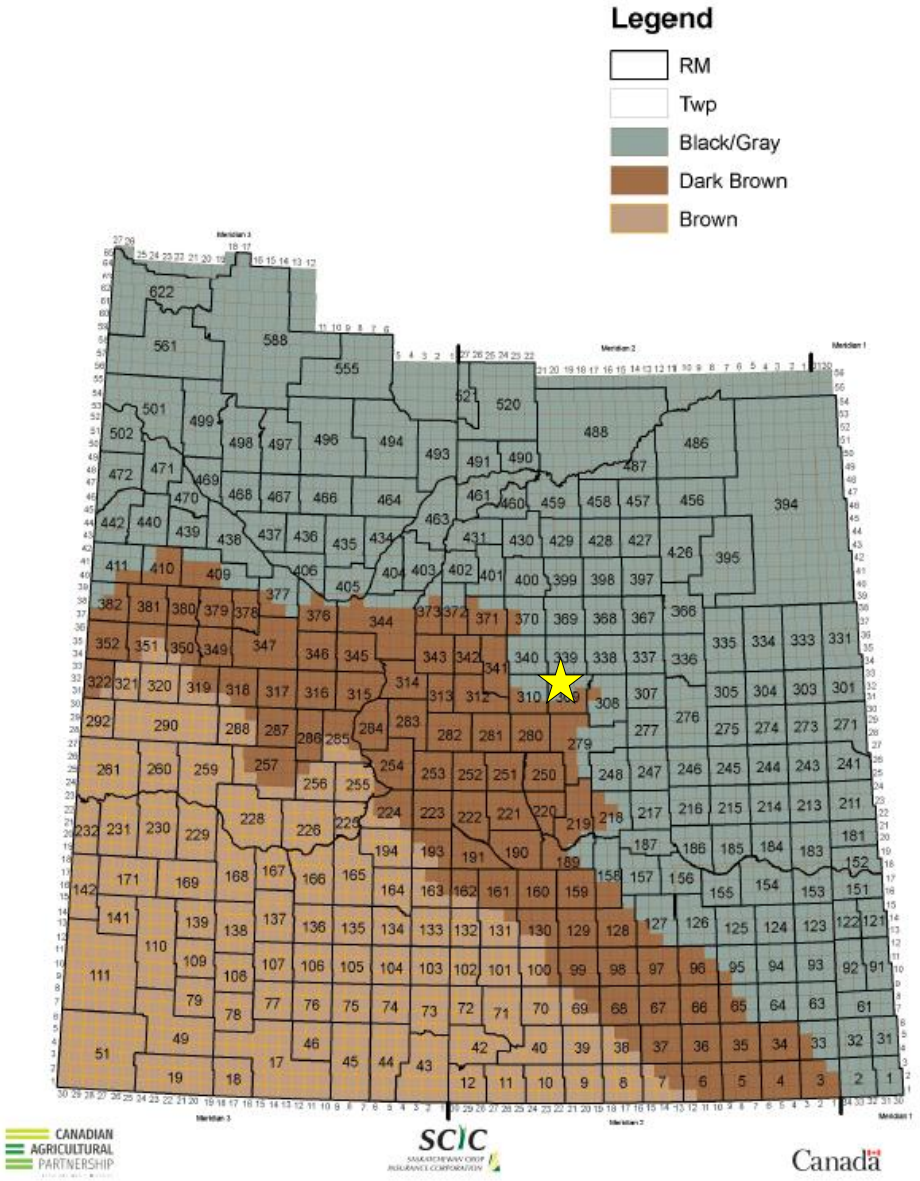
Objectives

Compare barley swath grazing to polycrop swath grazing over 2 yr for:

- Forage yield and quality (nutritive value)
- Effects on grazing beef cow performance
- Cost of production and cost cow^{-1} day^{-1}
- Effects on soil organic carbon

Study Location

- Livestock and Forage Centre of Excellence: Termuende Research Ranch, Lanigan SK
- Chernozemic Oxbow Soil
- 13.2 ha site
- 6 paddocks in total (2.2 ha each)



Source: Sask. Crop Insurance Corporation, 2019

Treatments

- Two grazing treatments:
  - Swath grazed CDC Maverick barley (*Hordeum vulgare*), swathed at soft dough stage in August
  - Swath grazed annual polycrop mixture, swathed at target growing degree days in September

- Each yr, dry pregnant beef cows were allocated to 1 of 2 replicated (n=3) grazing systems (treatments)

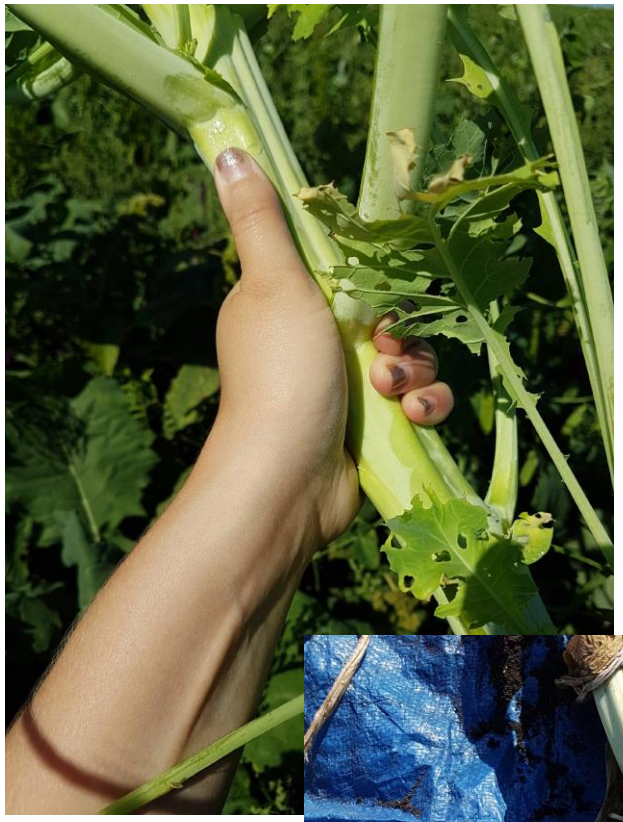
Annual Polycrop Mixture

- "Ultimate Annual Blend" with 40-10 forage peas (*Pisum sativa*)
  - Provided in-kind by Union Forage

Species composition of Union Forage Ultimate Annual Blend

Item	2017	2018
Hairy Vetch (*Vicia villosa*)	30%	30%
Crimson Clover (*Trifolium incarnatum*)	10%	10%
Italian Ryegrass (*Lolium multiflorum*)	25%	30%
Sorghum (*Sorghum bicolor*)	15%	0%
Winfred Forage Brassica (*Brassica napus* ssp. *biennis*)	10%	10%
Hunter Brassica (*Brassica rapa* syn.B *campestris*)	5%	10%
Graza Forage Brassica (*Raphanus sativa* ssp. *maritimus*)	5%	10%

(Union Forage, 2017; Union Forage, 2018)



Forage Data

- Forage Yield
  - Weights of pre-swath 0.25 m^2 quadrats used to estimate forage biomass yield on DM basis
- Forage quality
  - Dry and ground samples taken at the start and end of grazing trial analyzed for TDN, CP, NDF, ADF, Ca, P, S, and NO_3^-
  - NASEM (2016) model used to allocate feed based on cow body weight and forage nutrient density

Forage Data

- Forage Dry Matter Intake and Utilization
  - Weights of swaths pre- and post-grazing were used to estimate swath yield and animal dry matter intake

Cow Performance Data

- Body weights at start and end of trial measured over 2 consecutive days
- 1 d body weights measured every 14 d during trial
- Body condition score determined at start and end of trial
  - 5 point scale (Lowman et al., 1976)

System Economics

- Compare the costs of each crop to grow
- Cost cow^{-1} d^{-1} determined to compare treatments

Soil Carbon Analysis

- Soil cores were collected in Spring 2017, Spring 2018 and Fall 2018 at 6 locations in each paddock (3 upslope and 3 downslope)
  - Two depths: 0-5 cm and 5-20 cm
- Soil samples were ball-grounded and pre-treated to remove carbonates
- Soil organic carbon was measured using the LECO C632 Carbon Analyzer

Results

Forage Yield

Barley yielded higher than polycrop mixture

Biodiversity (Manns and Martin, 2018)??

Weed pressure and environmental conditions

- Botanical composition of polycrop:
  - Yr 1: brassica > legume > other > grass
  - Yr 2: other > brassica > legume > grass

Forage biomass of grazing systems over 2 yr (DM basis)

Item	Barley	Polycrop	SEM[1]	*P*-value
Yield (T ha^{-1})	9.8^{a}	7.1^{b}	1.58	<0.01

$^{a\text{-}b}$Within a row means with different letter differ ($P \leq 0.05$)

[1]SEM = pooled standard error of mean

Forage Quality

Chemical composition of forage at 2 sampling times over 2 yr (DM basis)

	Sampling Time						
	Start		End			*P*-value	
Item	Barley	Polycrop	Barley	Polycrop	SEM[1]	trt	time
DM[2] (%)	60.1^{a}	42.6^{c}	65.6^{a}	49.2^{b}	8.81	<0.01	<0.01
TDN (%)	60.1^{ab}	58.1^{ab}	59.6^{ab}	55.7^{b}	4.13	<0.01	0.06
CP (%)	10.5^{b}	15.2^{a}	9.7^{b}	13.6^{a}	2.21	<0.01	0.03
NDF (%)	57.8^{a}	45.8^{b}	58.6^{a}	51.5^{b}	3.80	<0.01	0.04
ADF (%)	36.7^{b}	39.0^{a}	37.9^{b}	42.4^{a}	5.12	<0.01	<0.01
Ca (%)	0.21^{b}	1.11^{a}	0.23^{b}	1.01^{a}	0.075	<0.01	0.57
P (%)	0.29^{a}	0.25^{ab}	0.25^{ab}	0.22^{b}	0.010	<0.01	<0.01
S (%)	0.20^{b}	0.59^{a}	0.20^{b}	0.50^{a}	0.057	<0.01	0.35
NO_3^- (%)	0.03^{b}	0.11^{a}	0.04^{b}	0.12^{a}	0.021	<0.01	0.58

[a-c]Within a row means with different letter differ ($P \leq 0.05$)

[1]SEM = pooled standard error of mean

[2]DM = dry matter, TDN = total digestible nutrients, CP = crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber, Ca = calcium, P = phosphorus, S = sulphur and NO_3^- = nitrates

Forage Utilization and Dry Matter Intake (Yr 1)

Higher dry matter intake and utilization was observed in barley than polycrop

Dry matter content (Lahr et al., 1983), anti-nutritional factors (Landau et al., 2000), and environmental conditions

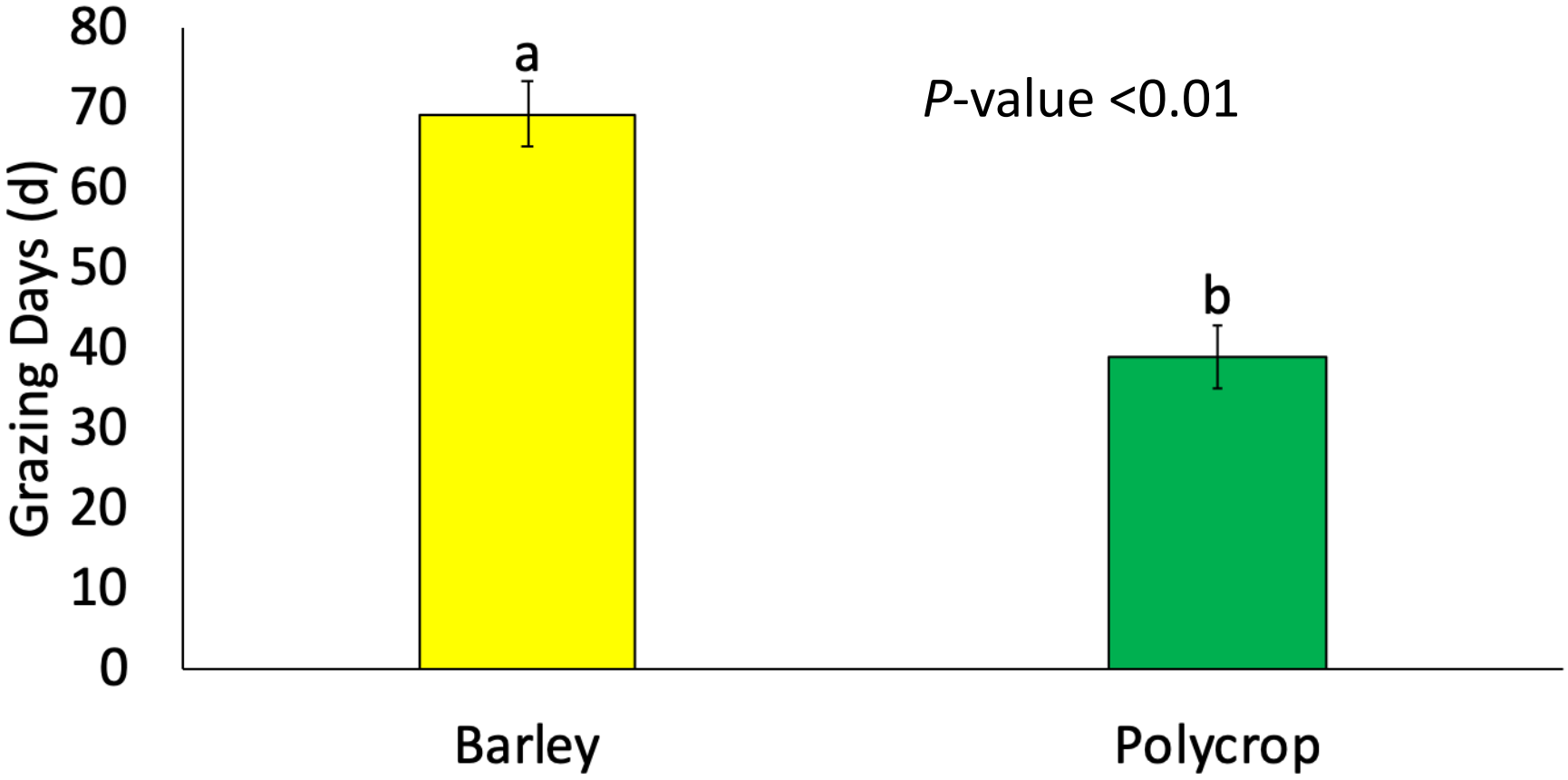
Yr 1 (DM basis)

Item	Barley	Polycrop	SEM[1]	*P*-value
DMI (kg cow^{-1} d^{-1})	20.4^{a}	12.6^{b}	0.913	≤0.01
Utilization (%)	61.1^{a}	43.5^{b}	1.289	≤0.01

$^{a-b}$Within a row means with different letter differ ($P \leq 0.05$)

[1]SEM = pooled standard error of mean

Grazing Days (Yr 1)



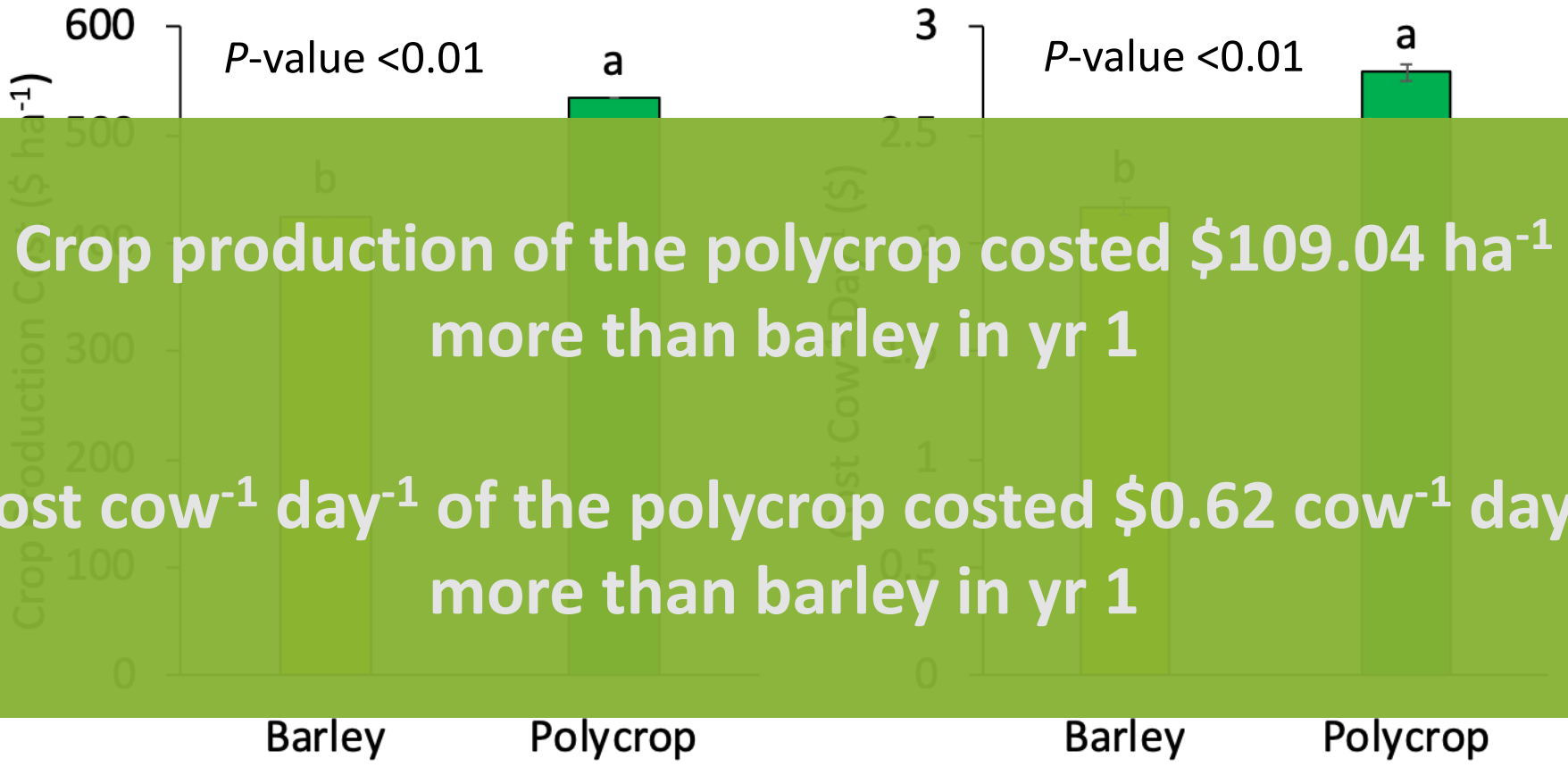
Grazing days of forage systems in Yr 1

[a-b]Bar means with different letter differ ($P \leq 0.05$)

Cow Performance (Yr 1)

- No differences observed in cow performance in yr 1, including body weight, body condition score, and average daily gain
  - Supplementation was needed

System Economics (Yr 1)



Crop production of the polycrop costed $109.04 ha^{-1} more than barley in yr 1

Cost cow^{-1} day^{-1} of the polycrop costed $0.62 cow^{-1} day^{-1} more than barley in yr 1

Cost of crop production and cost cow^{-1} day^{-1} of forage systems in Yr 1

[a-b]Bar means with different letter differ ($P \leq 0.05$)

Soil Organic Carbon

- No differences observed in total soil organic carbon in:
  - Downslope locations (at either depth)
  - Upslope locations at a depth of 0-5 cm

Net gains in soil organic carbon of polycrop in upslope locations at a depth 5-20 cm

Can be difficult to see changes in soil organic carbon over 2 yr

Total soil organic carbon (Mg ha^{-1}) in an upslope location of two grazing systems over 2 yr

Item	Sample Timing								
	Spring 2017		Spring 2018		Fall 2018			*P*-value	
Depth	Barley	Poly	Barley	Poly	Barley	Poly	SEM	trt	trt*time
5-20cm	62.04^{ab}	51.53^{b}	70.75^{a}	47.08^{b}	61.73^{ab}	59.88^{ab}	4.158	0.02	<0.01

$^{a-b}$Within a row means with different letter differ ($P \leq 0.05$)

^{1}SEM = pooled standard error of mean

Conclusions

- Yield of barley was higher than polycrop
- No significant differences in cow performance between barley and polycrop
- Polycrop costs more to produce than barley
- Soil organic carbon increased in the location and depth with the lowest levels of carbon

Implications

- There is no silver bullet
- Weed control in polycrop is needed
- Test feed for nutritive value
  - Watch levels of sulfur and nitrates
- Always have a backup plan when extensive grazing
  - Weather can be unpredictable
- Potential to increase soil organic carbon over short period of time in areas with low carbon levels

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