Agriculture and Agri-Food Canada Agriculture et Agroalimentaire Canada

Multi-Species Annual Forage Crops Integration With Annual Mono-Crop Production

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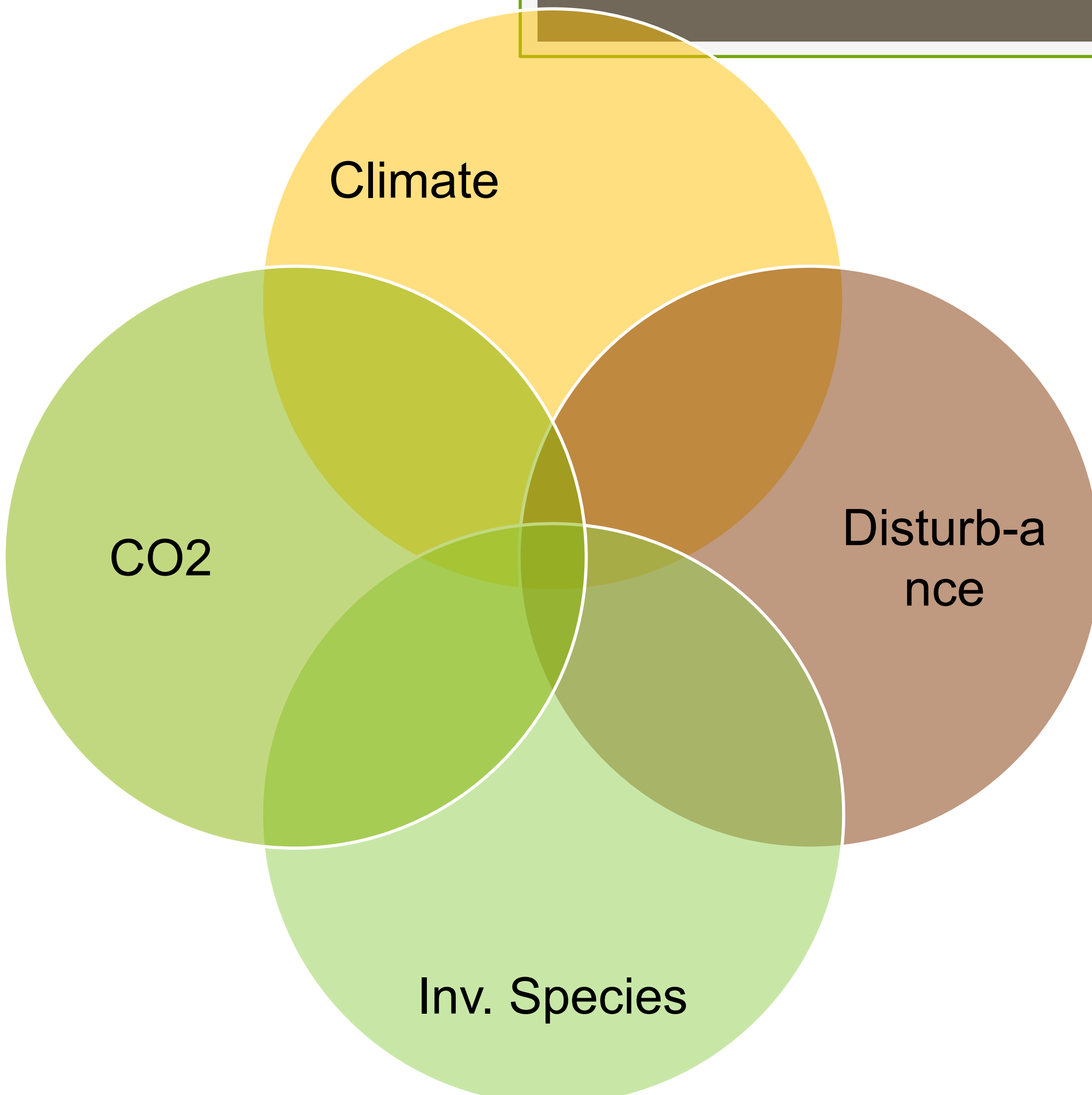
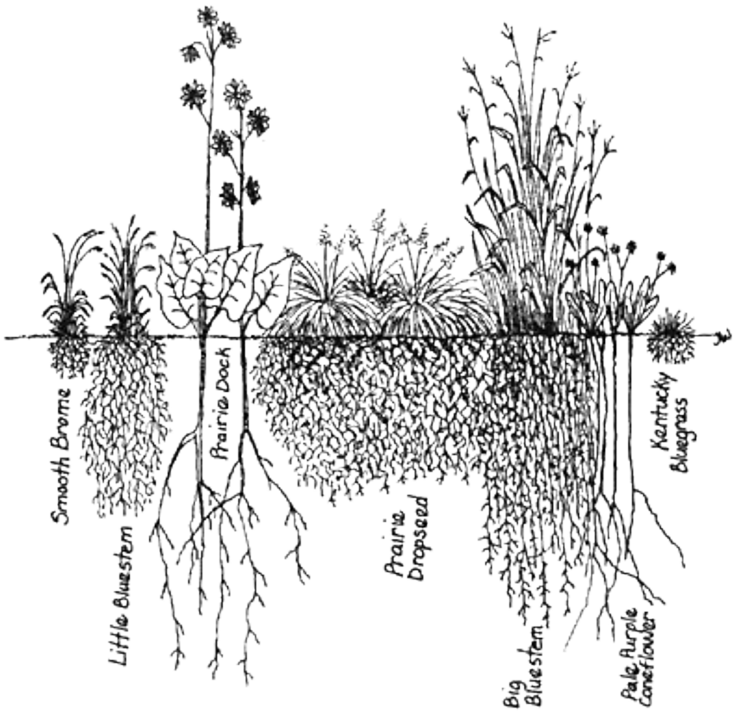
Canada

Things to be covered

- The setting
- What needs to be considered
- What are Functional Groups
- The Swift Current Experience
- Examples of selection
- Summary


Climate
CO2
Disturb-a
nce
Inv. Species

Root Advantage



www.roots-for-wild.org

Microbial communities (Schellenberg et al 2008)

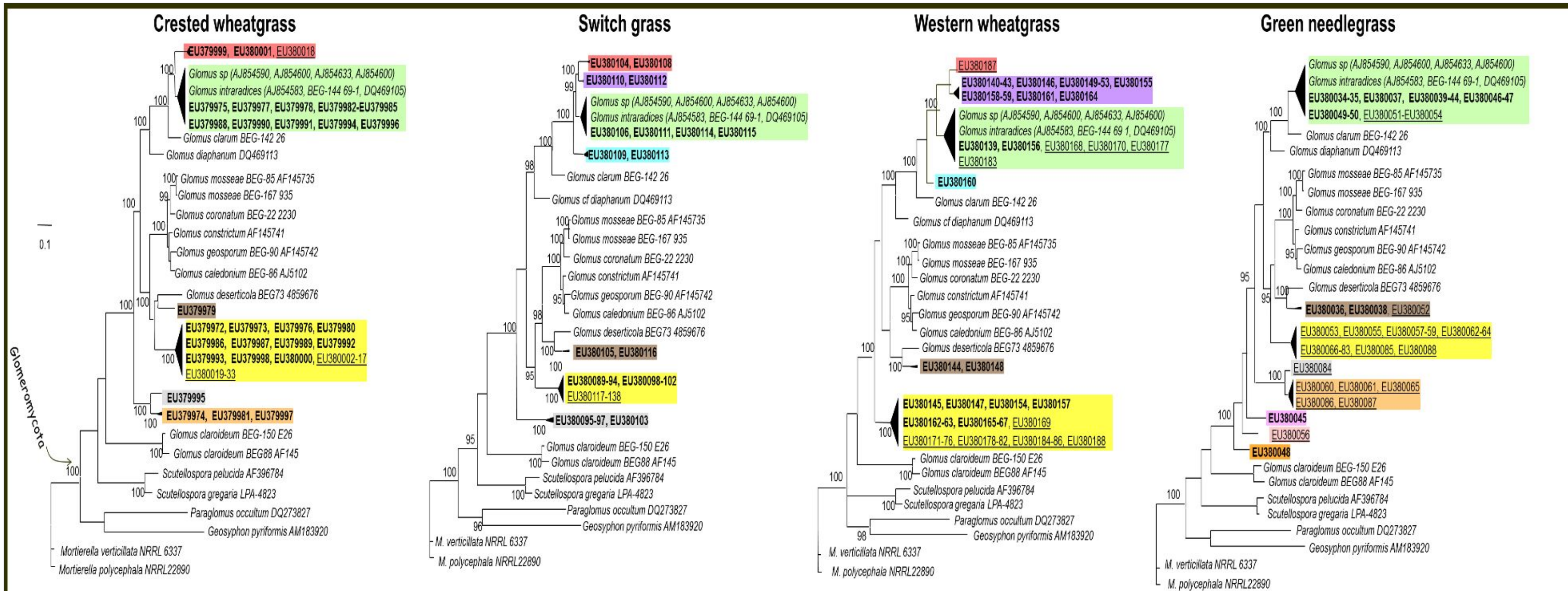


Figure 1. In **bold**, code numbers in GenBank for DNA sequences obtained from 0 to 15 cm depth of root sampling. Underlined, are codes for DNA sequences obtained from roots of 30 to 45 cm depth. In *italics*, codes of DNA sequences of known Glomeromycota, downloaded from GenBank. In each three, different colors represent different ribotypes, defined as groups having less than 0.05 substitutions per site. Numbers in the branches indicate posterior probabilities supporting the consistency of the clade. *Mortierella sp (NRRL 6337, NRRL22890)* was used as a outgroup.

Cover Crops or Forage Crops?

- “Cover crops are plants seeded into agricultural fields, either within or outside of the regular growing season, with the primary purpose of improving or maintaining ecosystem quality” (Midwest Cover Crop Council)
- This is not new 1938 Soils and Men, Yearbook of Agriculture(USDA)

Perceived benefits

- Enhance biodiversity
- Increase soil infiltration, leading to less flooding, leaching, and runoff
- Reduce erosion
- Retain nutrients
- Add nitrogen through fixation
- Combat weeds
- Break disease cycles

(Midwest Cover Crops Council)

The Literature

- Most important living organism in soil are the higher plants which are responsible for all the organic matter…(Allison 1973)
- High confidence in the following
  - Appropriate species combination increase productivity and nutrient retention (Hooper etal 2005; Lithourgidis et al 2011)
  - Invasive undesirable species affected by plant community (Hooper et al 2005)
  - Diverse plant assemblages deal with diverse climatic impacts better (Hooper et al 2005; Isbell et al 2015)

The Literature

- Rotation benefits are driven by species rotation and microbial diversity (Hacker et al 2015)
- Plant diversity impacts microbial community structure (Yang et al 2010)
- Plant diversity thus impacts nutrient mobilization such as phosphorous (Hacker et al 2015)
- Crop species diversity in the United States over a 34 year period is dropping (Aguilar et al 2015).

Increased interest

- New terminology? Regenerative agriculture “system of farming principles and practices that increases biodiversity, enriches soils, improves water cycles and enhances ecosystem services”(Soloviev 2017)
- Sustainable Intensification ??
- New National research initiative (Foundation for Food and Agriculture Research 2017)USDA
- Cover crops essential to maintaining crop productivity when tillage reduces (Wittwer et al 2017)
- Appropriate selection of mixtures can stimulate subsequent productivity through <u>return of biomass and nutrients to soil</u> (Barel et al 2017)

So why do more research?

- Studies tend be in higher moisture regions than semiarid
- Will multispecies annual crop systems (polycultures) work under drier conditions?

USDA United States Department of Agriculture

Cover Crop Chart

AREA 4 SCD

GROWTH CYCLE	PLANT ARCHITECTURE	RELATIVE WATER USE
A = Annual	= Upright	= Low
B = Biennial	= Upright-Spreading	= Medium
P = Perennial	= Prostrate	= High

COOL

WARM

GRASS	BROADLEAF				LEGUME				GRASS
A BARLEY								A AMARANTH	A FOXTAIL MILLET
A OAT	A/B CANOLA	A/B CAMELINA						A BUCKWHEAT	A PEARL MILLET
A WHEAT	A/P MUSTARD	A PHACELIA	A FIELD PEA	A BERSEEM CLOVER	A/B VETCH	A COWPEA	A CLUSTER BEAN	A QUINOA	A PROSO MILLET
A CEREAL RYE	A RADISH	A FLAX	A LENTIL	A CRIMSON CLOVER	P BIRDSFOOT TREFOIL	A/P FENUGREEK	A SUNNHEMP	P CHICORY	A GRAIN SORGHUM
A TRITICALE	B TURNIP	A KALE	A LUPIN	B/P RED CLOVER	A/B SWEET CLOVER	P PIGEONPEA	A MUNG BEAN	A CUCURBITA	A SUDAN GRASS
A ANNUAL FESCUE	B BEET	A SPINACH	A/P MEDIC	P WHITE CLOVER	P SAINFOIN	A CHICKPEA	A SOYBEAN	A SAFFLOWER	A TEFF
P SALINE TOLERANT	A/B CARROT	A/B CHARD	P ROUNDHEAD LESPEDEZA	P KURA CLOVER	P ALFALFA	A FAVA BEAN	A/P PEANUT	A SUNFLOWER	A CORN

V 2.1. January 2016

Additional Information

Considerations

- Habitat
  - Soils
  - Moisture
- Low productivity
- Poor soil fertility
- Production risks

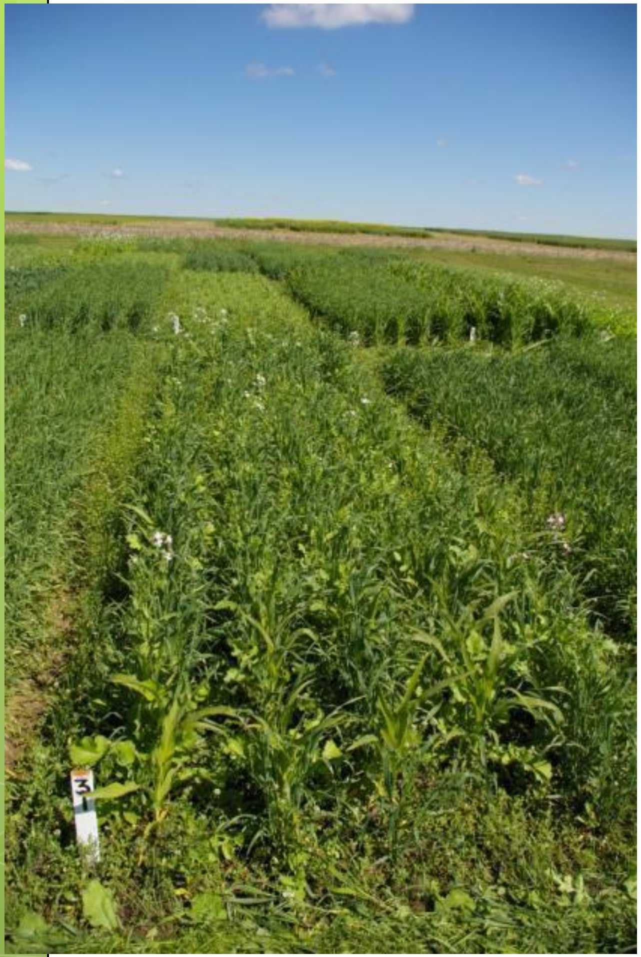
The Swift Current Experience

- Polyculture study
- 12 species mix in rotation
- Species placement
- Role within Organic Systems

2017 Cover crop seedings for Organic Trials

- 3 different blends
- Seeding Date: June 19, 2017
- Precipitation received since April: 8mm
- Photo: August 2, 2017
- Seeding date critical

Polyculture Study



Experimental Design

- Four functional groups, 12 species

Cool Season Grasses (C_3 plants)

barley, oats, triticale

Warm Season Grasses (C_4 plants)

corn, sorghum, millet

Legumes (nitrogen fixers)

forage pea, field pea, hairy vetch

Brassicas (root crops)

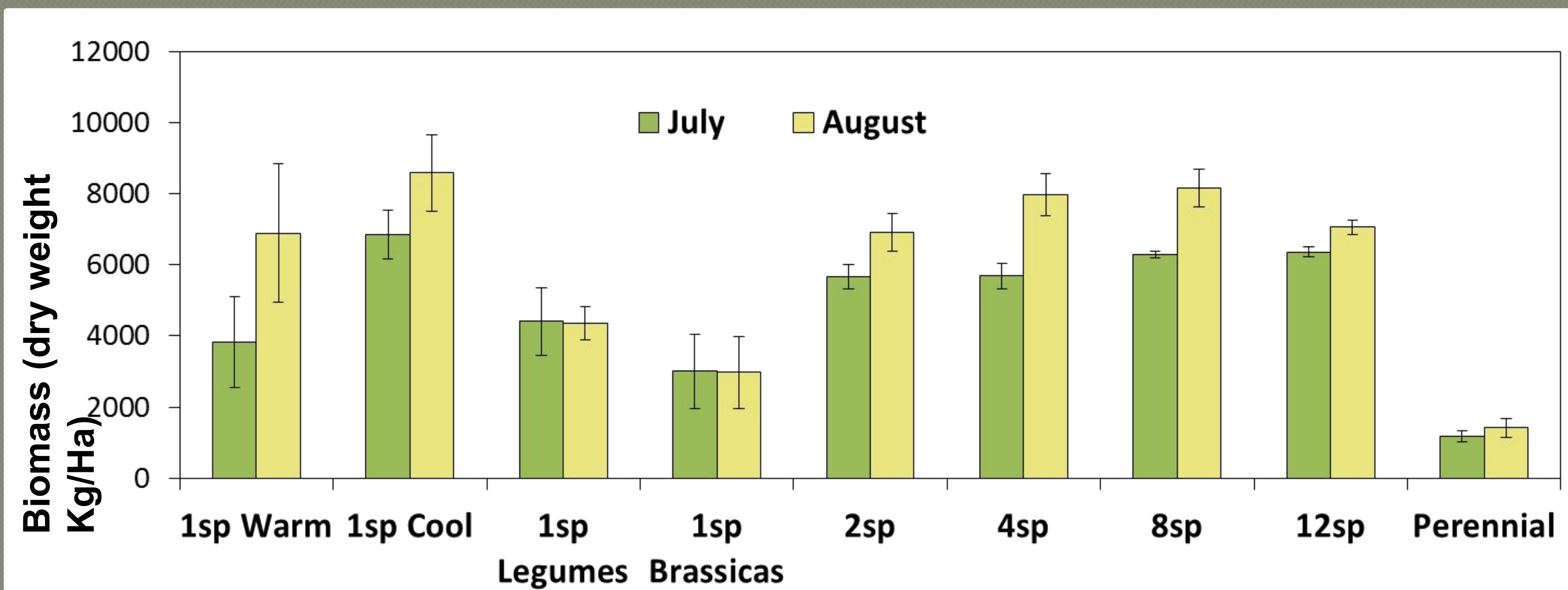
forage radish, turnip, kale

Experimental Design

- 34 treatments: monocultures, 2, 4, 8 & 12 species mixtures seeded into same plot 4 years in a row, perennial comparison
- 4 replicates, 136 plots
- Seeded early June, harvested late August
- No inputs
- Seed rate: equal representation of species based on 100 pure lives seeds per metre.

Observations

- Biomass Production (2013)
  - Mixtures had higher biomass production than most monocultures
  - Perennial forage was in an establishment year and expected to have low biomass



Observations

- Species Composition:
  - Some species did not perform well in monocultures or mixtures

Sorghum

Kale

Other benefits

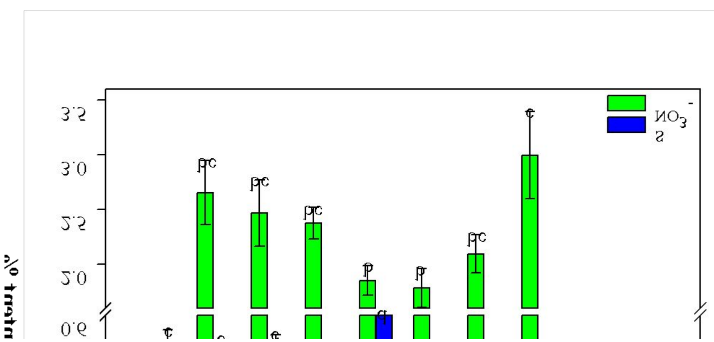
- Maintain cover thus maintaining functioning soil ecosystem
- Decreased insect damage for brassicas in mixtures versus monocultures
- Increase in water stable aggregates over a four year period despite removal of 90+% of residue
  - Monocultures were not different for non-grasses except sorghum poor establishment

Adaptation

- **Persian Clover**
  - Winter annual (weed control)
  - Southern US, some drought tolerance
  - Fertile, poor drain, heavy clay loam
  - Naturally reseeds
- **Crimson Clover**
  - winter annual (naturalizes)
  - Low temp tolerance
  - Well-drained, fertile loamy soil
  - Sandy to clayey soil with slight acidity
- **Berseem Clover**
  - Summer annual (weed control)
  - Fertile soils loam to clay soils, well drained
  - Performs better in high moisture
  - pH 6 to 7.8

- Slough grass
  - Annual grass
  - Tolerates high moisture soils
  - Good seed producer
- American vetch
  - Common throughout prairies
  - Nitrogen fixer
  - Good seed producer
- Breadroot
  - Large root
  - Nitrogen fixer
  - Much more common than present
- Slender milkvetch
  - Easy to establish
  - Good growth the first year
  - Drought tolerant once established
  - Good seed producer

Initial 1st yr grazing results



- good grazing management is needed when grazing Brassica species.
- unless changes in grazing management (never turn a hungry animal onto the pasture that they are not adapted to) and supplementation (high quality trace mineral mix and the salt should be iodized) occurs.

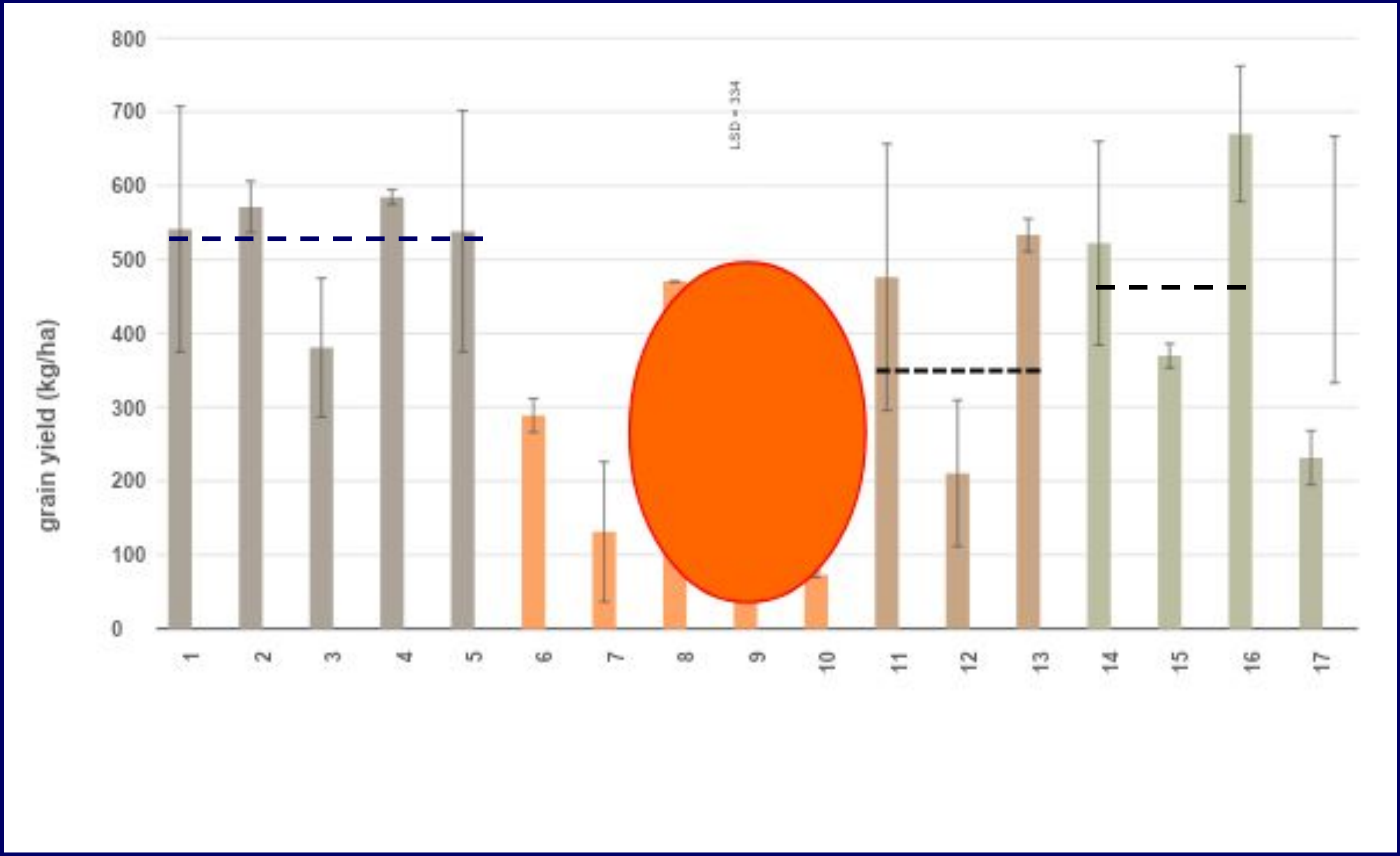
Soil Nutrients

- No increase noted for soil nutrients except P.
- Question: So where is the increase in nutrients that has been suggested?
  - Barel et al. (2018) found release of nutrients is based on quality of residue and its decomposition rate.
  - Studies at Swift Current have found 2 to 3 years are required to note increase in N in terminated alfalfa stands.

Monocrop Production

- Polyculture Study
- The barley feedback crop in 2016 revealed that the highest barley biomass was found on the tilled plots that were previously seeded to oats monoculture (Treatment 6) (Table 68).
- The lowest barley biomass on the tilled plots was found on the plots previously seeded to barely monoculture (Treatment 7).
- All untilled plots had much lower barley biomass than the tilled plots.

Effect of previous (2017) cover crops on grain yield of the 2018 lentil cash crop (Blend 3 – legumes, grasses, phacelia)



Disease

Diseas
e

Root rot severity in legumes - e.g. chickling vetch:

2017:

blend 1 < blend 3 ≤ monocrop ≤ blend 5
(- 31%)

2018:

blend 1 < blend 3 = monocrop
(- 40%)

Blend 1 – grasses, brassicas
Blend 3 – legumes, grasses, phacelia
Blend 5 – less competitive brassicas and grasses, legumes, phacelia

Most fungi isolated from affected roots were *Fusarium* species

Additional Research??

- How much residual is needed?
- How does the mixture impact the following crops? Are there mixtures that may have greater benefit for certain crops that follow?
- Disease transfer?
- Weeds: Are multi-species mixtures a solution or a means of introduction?
- Economics

Things to remember

- Studies tend be in higher moisture regions than semiarid
- Will multispecies annual crop systems (polycultures) work under drier conditions? Some benefits do occur, additional information is required to determine a long term benefit, appropriate species, seeding rates, microbial community impacts… This is just the beginning. This is not a system restricted only to forage/livestock systems. Great deal of interest for weed control and low input operations.

Summary

- Know your environment
- Understand the limitations of the site
  - Light soils, heavy soils
  - Limited precipitation
- Select species that work for your environment and goals
- Understand what they contribute to your mix

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Questions?


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