Crop Rotations Under Irrigation

Irrigation Agronomy Workshop

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Crop Rotation

- A planned sequence of crops repeated over time on the same land base
- Webster – “to preserve the productive capacity of the soil”
- Historically – fallow and wheat - cornerstone
- Goal – a plan suited to farming operations
  - Integrated with livestock production

Why Crop Rotation?

- Widely used prior to 1950's for beneficial effects on succeeding crops and to control weeds, insects, and diseases.
- Legumes reduced N fertilizer requirements
- High crop prices favour monoculture
- Low crop prices favour crop rotation

Rotations

- Benefits
  1) Reduction in soil erosion and water runoff
  2) Reduction in N fert requirement with legumes
  3) Improved soil tilth with legumes
  4) Break weed, disease, and insect cycles
  5) Redistribution of labour
  6) Value added potential for products

Rotations

- Challenges
  1) Greater variety of equipment required
  2) More knowledge and expertise required
  3) Time constraints due to growing diversity of crops
  4) Reduced net return when wheat and canola are high priced

Agronomic Principles

- Crop rotation influences yield
  - Impacts water use efficiency
    - Yield of harvested crop from available water (rainfall, irrigation, and soil storage)
  - Factors – rooting depth, water extraction, soil structure, residual nutrients

Relative Rooting Depth

Deep	Moderate	Shallow
Alfalfa	Barley	Field Pea
Safflower	Canola	Flax
Sunflower	Mustard	Lentil
Forage Grass	Wheat	

Irrigated Crop Water Use

Crop	Water Use*	Crop	Water Use*
Alfalfa forage	620 mm	Wheat, CPS	460 mm
Potato	520 mm	Malt barley	430 mm
Grain Corn	520 mm	Feed barley	400 mm
Fababean	510 mm	Flax	410 mm
Sunflower	510 mm	Alfalfa seed	400 mm
Brown/oriental mustard	480 mm	Field pea	480 mm
Yellow mustard	480 mm	Cereal silage	390 mm
Canola	480 mm	High moisture barley	390 mm
Soft wheat	480 mm	Dry Bean	380 mm
Durum wheat	480 mm	Red Lentil	275 mm

Sources: Irrigation Scheduling Manual – Sask Ministry of Agriculture
Irrigation Management Field Book – AB Agriculture and Rural Dev.

* Growing season

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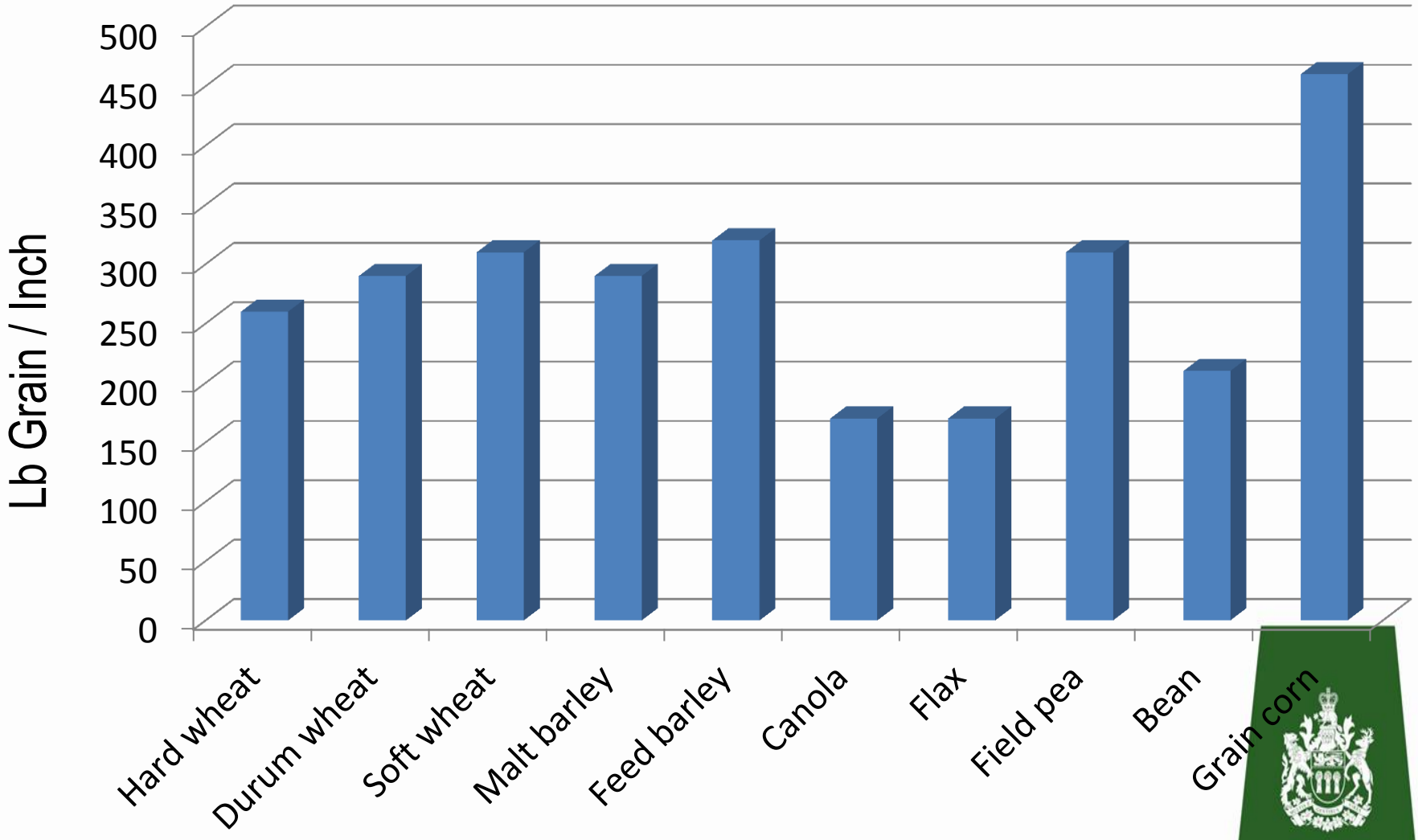
Grain production/inch



Source: ICDC Budget Book

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Agronomic Principles

- Crop rotation influences yield
  - Affects nutrient cycling - pulse crops
  1) Nitrogen fixation
  2) Non N benefit – nutrient distribution in residue eg K
  - Differential nutrient removal balances soil supply – S with canola, Zn with beans
  - Effect of previous crop on current crop
    - Crop type – cereal, broadleaf
    - Yield higher on stubble of another crop type
  - Reduced pest impact

Nutrient Uptake

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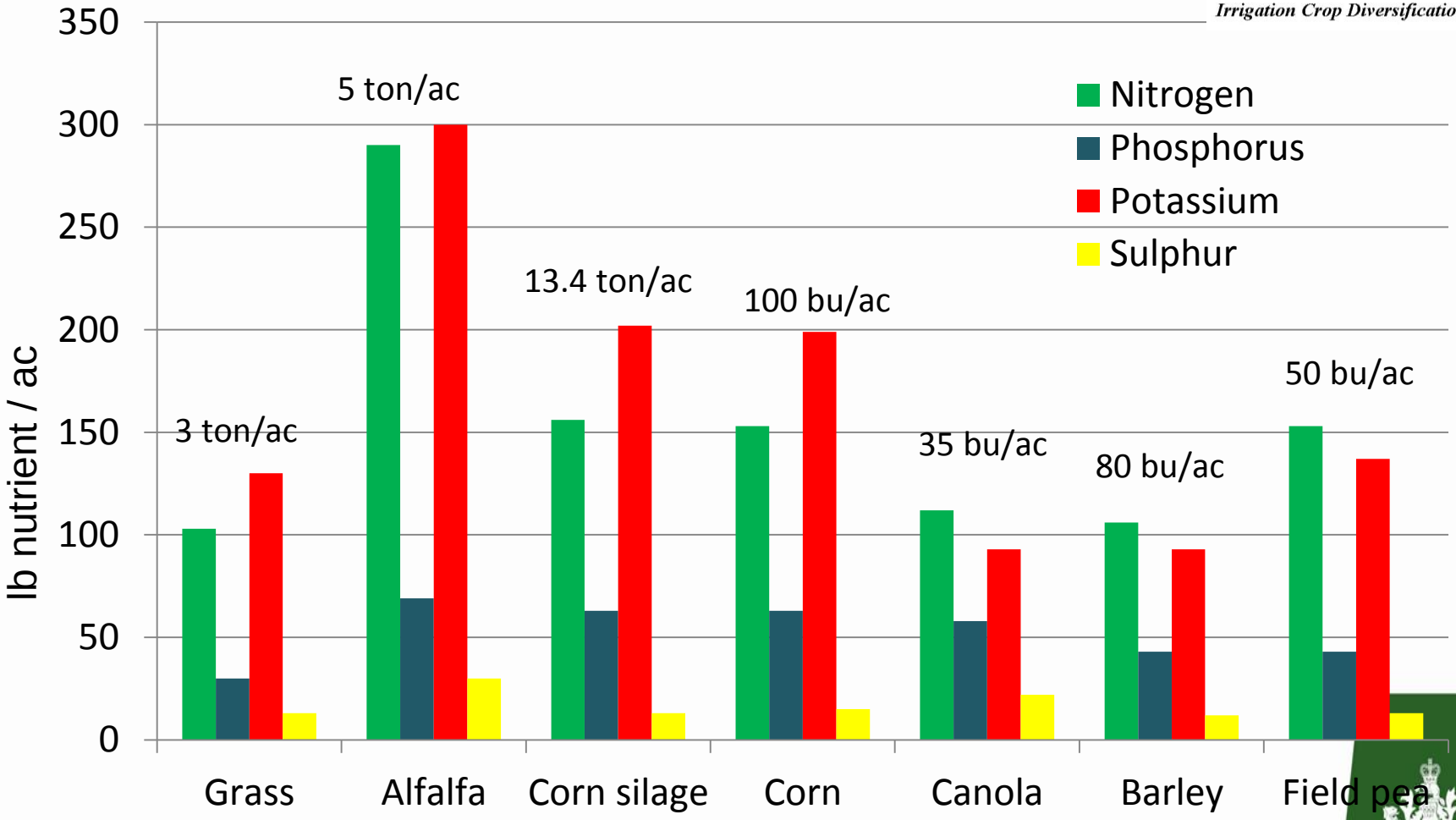

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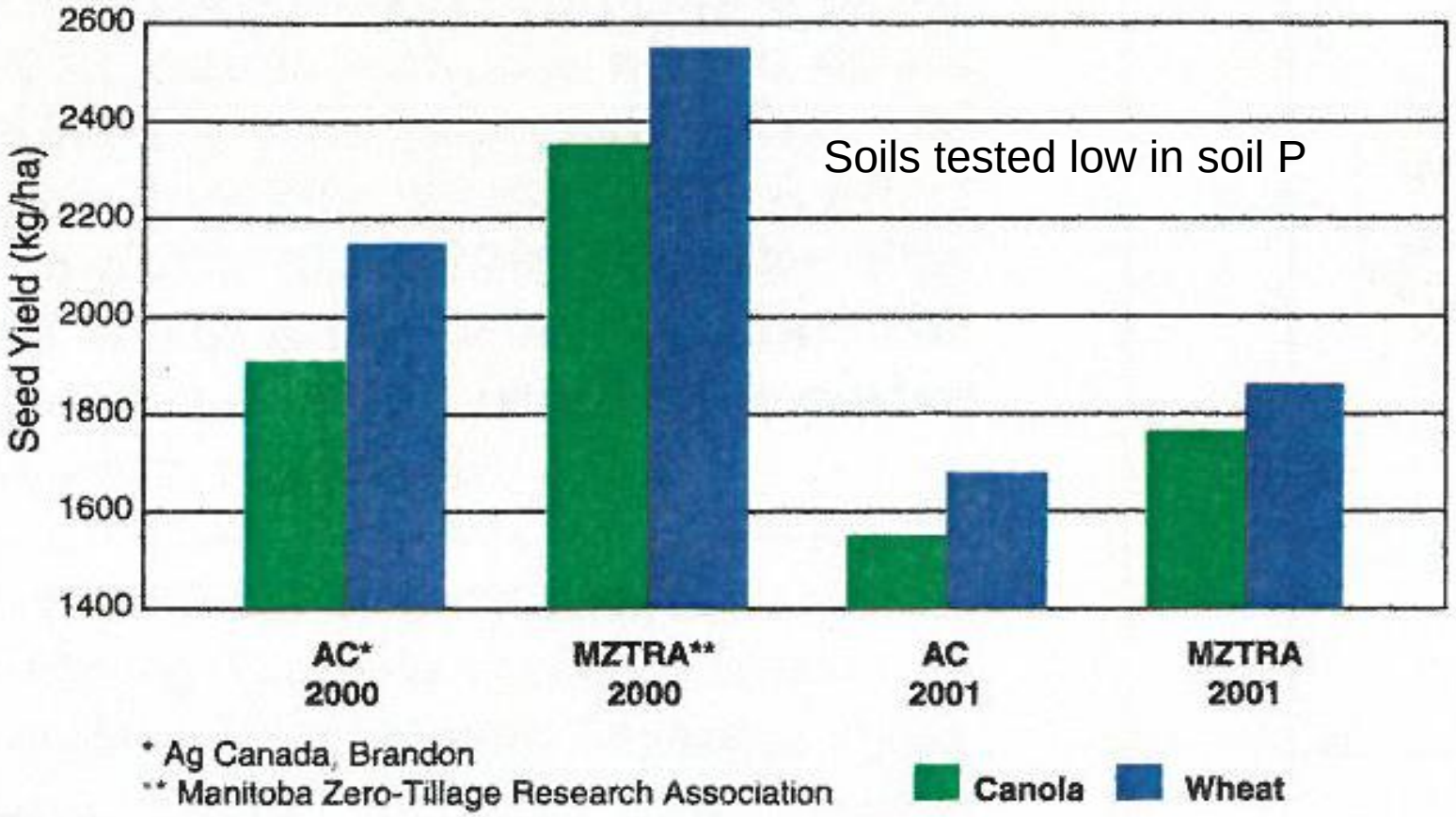
Flax seed yield
Canola vs wheat stubble



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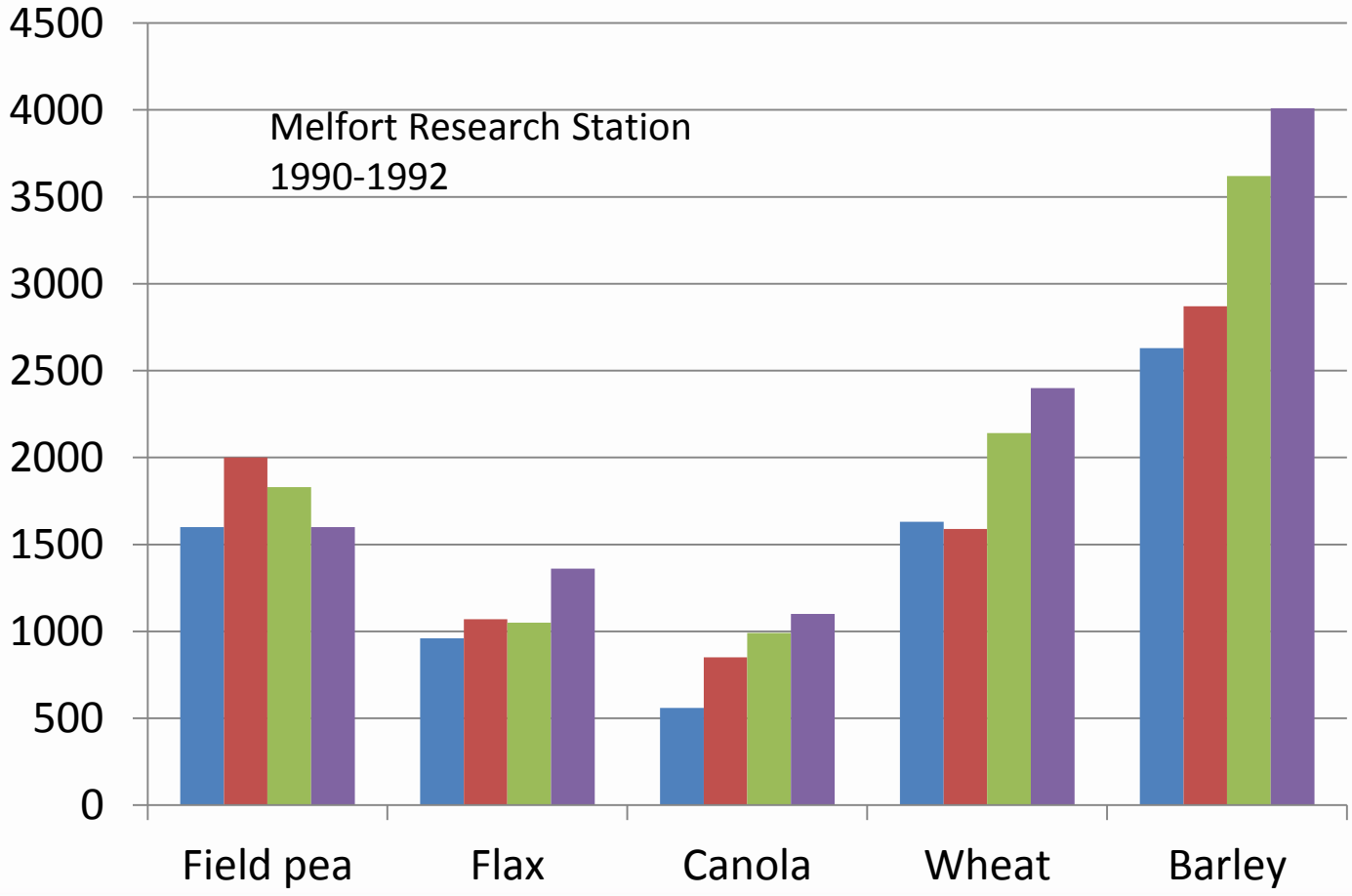
Yield of Crops Grown on Different Stubble Types



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- Own
- Cereal (wht bly av.)
- Oilseed (flax can av.)
- Field Pea

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Cropping Sequence

- Cereal grains yield higher on oilseed and pulse stubble than on cereal stubble
- Flax reduces wheat stubble yields – weed control inferior with flax
- Forage as green manure feasible
- Grassy weed issues greater with stubble cropping
- Mixtures of cereal and forage suppress weeds

Crop Pest Management

- Sclerotinia needs at least 3 year break from susceptible crops – pulse, canola, alfalfa, flax
- Cereals and grasses are break crops for sclerotinia

Disease under Irrigation

- Long lived diseases
  - Less specific disease pathogens
  - Survive in soil up to several years
    - Sclerotinia in canola, mustard, legumes, vegetables
    - Fusarium wilt in flax
    - Ergot in cereals and grasses
    - White rust in canola and mustard
  - Control measures
    - Need resistant cultivars and crop rotation
    - 2-4 years between susceptible crops

Disease under Irrigation

- Short lived diseases
  - Affect only specific crops
  - Overwinter on crop residue and seeds
    - Flax rust, sunflower rust, early blight of potato, blackleg of canola, bacterial blight of pulses, ascochyta of pulses, leaf spots of cereals
  - Crop rotation

Disease under Irrigation

- Soil borne diseases
  - Pathogen with very broad host range
  - Increase under continuous cropping
    - Common root rot on cereals and grasses
    - Take-all root rot with continuous wheat
    - Seedling blight and root rot on broadleaf crops
  - Control measures
    - Crop rotation (2-3 years between susceptible crops)
    - Adequate soil fertility and soil tilth
    - Use seed treatments and disease free seed
    - Row cropping or wider row spacing

Rotations under Irrigation

- No need for fallow to conserve moisture

- Canola – Wheat – Field Pea – Barley
- Canola – Durum – Field bean – Barley
- Flax – Canola – Durum – Field Pea
- Canola – Wheat – Canola – Wheat
- Canola – Canola – Soft Wheat

Moisture Management Strategies

- Crop residue management
  - Increases water conservation
    - Conservation tillage
    - Snow trapping
    - Deep ripping
- Root zone storage of soil moisture
  - Tillage increases loss of moisture
  - Stubble seeded crops require seeding time rain without irrigation

Crop Management

- Under-fertilization reduces yield and residue and water use
- Crop water use – canola and oat hay < spring wheat
- Legume and grass hay < than spring wheat

Crop Sequence

- Why the ruccous?
  - Disease pressure
  - Continuous cropping –fallow no longer present
  - Reduced tillage, direct seeding, zero tillage
  - More broadleaf crops
  - Reduced cropping intervals
  - Pest resistance to “tried and true” solutions
    Weeds Insects Diseases

Benefits of Organic Matter

- Organic residues build soil health
  - Improve soil organic matter
  - Improve soil tilth
  - Improve soil structure – reduces bulk density
  - Improve moisture holding capacity
  - Improve nutrient supplying power
  - Tightens up nutrient cycling
  - Reduces risk for erosion

Impact of Irrigation

- Trish Meyer Thesis –
  - Evaluated soil under intensive irrigation at Outlook and flood irrigation at Maple Creek
  - Only slight increase in soil organic matter and in nutrient supplying power from the soil due to irrigation
  - Major benefit from increased fertilization rates

Rotations – Target Yield Economics

Crop	Target Yield	Net Revenue ($)	
Dry Bean	50 bu	$517	(1)
Corn Silage	24 T	$509	(2)
Grain Corn	150 bu	$442	(3)
Canola	70 bu	$363	(4)
Durum	90 bu	$340	(5)
Soft Wheat	100 bu	$298	(6)
Field Pea	75 bu	$293	(7)
Hard Wheat	80 bu	$289	(8)
Flax	50 bu	$254	(9)
CPS Wheat	80 bu	$244	(10)
Malt Barley	100 bu	$186	(11)
Milling Oats	150 bu	$130	(12)
Alfalfa (3 cut)	5 T	$121	(13)
Cereal Silage	14 T	$113	(14)

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Dry Bean >

Corn (silage & grain) >

Field pea >

Wheat cereals >

Flax

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Rotation – Average Yield

Crop	Average Yield	Net Revenue ($)
Dry Bean	45 bu	$412 (1)
Durum	80 bu	$254 (2)
Soft Wheat	90 bu	$226 (3)
CPS Wheat	75 bu	$204 (4)
Hard Wheat	70 bu	$201 (5)
Canola	55 bu	$183 (6)
Grain Corn	100 bu	$142 (7)
Flax	40 bu	$128 (8)
Field Pea	55 bu	$123 (9)
Corn Silage	16 T	$113 (10)
Malt Barley	85 bu	$ 85 (11)
Milling Oats	120 bu	$ 43 (12)
Alfalfa (3 cut)	4 T	$ 26 (13)
Cereal Silage	12 T	$ 23 (14)

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Dry Bean >

Wheat Cereals >

Canola >

Grain Corn >

Flax >

Field Pea

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Sclerotinia

Inclusion of legume

- Black / Gray soils
  - Economics of continuous cropping
    - Economics less promising than shorter F-W-W, GM-W-W or mixed F-cereal-forage system
    - Legume containing systems improved soil quality
    - Legume systems reduce weeds and insects
    - Requires better management, more labour, and varied equipment

Use of fertilizer

- Increase net returns
- Increases efficiency of moisture use by stimulating root growth
- Improves moisture conservation and snow trapping by increasing surface crop residue
- Improves long-term soil productivity by increasing content and quality of OM

Ideal crop rotation

- Flexibility in crop selection in response to soil moisture, economics, and pests
- Agronomic practices influence OM%, soil pH, soil biota activity, nitrate leaching, CO_2 release from soil, pesticide contamination of groundwater

Rotation U - Lethbridge

- 10 year irrigated rotation
  - Started in 1911 – ten 1 ac plots
  - Three years alfalfa – wheat – sugar beets – three years alfalfa – barley – oats
  - Fertilization – 30 t/ac manure every 5 years
    - 100 lb 11-48-0 three years in ten on half of 1 ac plots
    - Healthy grain yields
      - 112 bu barley/ac
      - 134 bu oats/ac
      - 101 bu wheat/ac

Rotation U - Lethbridge

- Conclusions
  - Soil N and organic matter have increased since 1911
  - N from manure and soil has been adequate
  - P deficiency in unfertilized half of alfalfa and row crops (manure without P fertilizer not adequate to replace P removal

Irrigated Rotations

- 10 year rotation – barley, oats, alfalfa, alfalfa, alfalfa, sugar beet, wheat, alfalfa, alfalfa, alfalfa
- Trends – general upward increase in yields
- Alfalfa suffered from bacterial wilt and crown rot and phosphorus deficiency

Weakness of Research

- Limited number of crops
- Site selection – uniform topography, medium textured soils
- Change in cultivars and management practices

Lessons from Organic Farms

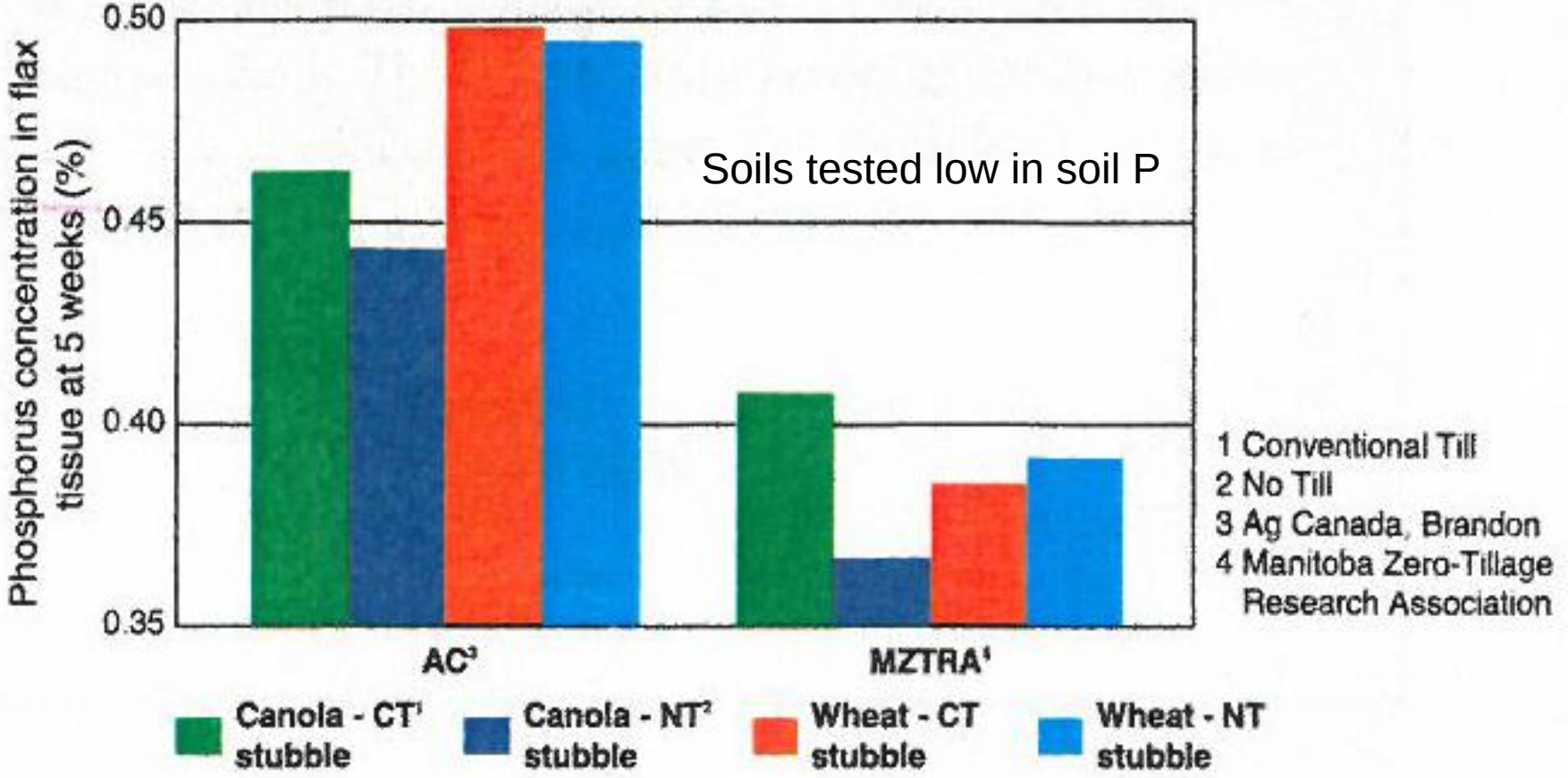
- 1) Diversity of crops
  - Early and late seeded crops, winter crops, green manure crops
    - Helps with weed control
- 2) Crop selection

- Grass – small grains – wheat, barley, oats, rye, corn
- Broadleafs – sunflower, buckwheat, mustard, canola, flax
- legumes – alfalfa, clover, vetch, pea, bean, lentil

Lessons from Organic Farms

- 3) light feeding and heavy feeding
  - Flax and buckwheat vs corn and wheat
- Feed the soil so it can feed the crop
- Green manure crops – eg clover, alfalfa
  - N fixing, deep penetrating root, builds OM, diverse soil MO, soil structure, WHC,
- Grass –extensive root system
- Livestock diversification

Effect of Stubble and Tillage System on P uptake in Flax



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Crop Rotation Wisdom

- Dwayne Beck – Dakota Lakes Demo Farm
- There is no “Best” rotation. A rotation will not work every year under every circumstance.
- Bad rotations can work well for a while and good rotations fail at times due to weather or other uncontrollable factors.

Crop Rotation Wisdom

- Chemfallow less effective at breaking weed, disease and insect cycles as are black fallow, green fallow or producing a well chosen crop
- Sequence crops to prevent volunteers from becoming a weed problem.
- Livestock producers can more easily introduce diversity eg. perennial forages

Crop Rotation Wisdom

- A two season interval between growing a crop type is preferred. Some broadleaf crops require more time.
- Adjust rotations to changes in markets, soil, climate, and enterprise
- Seek advice but do your own cooking.

Crop Rotation Wisdom

- Desire to increase diversity and intensity must be balanced with profitability
- Soil moisture storage is affected by surface residues, inter-crop period, stubble snow catch, rooting depth of crop, soil characteristics, precipitation, others
- Crops destined for direct human food pose highest risk and offer highest returns

Crop Rotation Wisdom

- Rotations that vary in crop sequence or crop interval guard against pest species shifts and minimize probability for resistant, tolerant, and adapted pests
- “I have no better chance of designing the best rotation for you than I have of choosing the best spouse for you.”

Crop Rotation Summary

- Soil testing useful tool to tailor nutrient applications
- Cropping sequence affects yield – cereal crop higher yielding on oilseed stubble
- Flax yielded better after wheat than after canola
- Flax reduced wheat yields
- Legume forage or green manure crop helped suppress weeds
- Plant disease found in wet regions

Crop Rotation Summary

- Moisture availability during grain fill period most critical
- Fallow degrades soil quality – OM loss, reduced nutrient supply, reduced MO activity, increased erosion
- Tools – grass/legume forage crops, green manure, legume in rotation, apply farm yard manure, apply fertilizer,

Crop Rotation Summary

- Benefits – soil productivity, soil tilth
- Deterrents – cash for inputs, weather risk
- Legumes reduced energy inputs and improved energy efficiency
- Following crop effects
  - soil moisture, residual fertility, pest populations

Successful Crop Rotations

- Avoid crop damage from residual herbicides
- Control volunteer crop
- Adjust rotation for soil characteristics
- Need flexibility to deal with new problems that arise, adjust crop mix, and implement new technologies

Recommended Cropping Intervals

TABLE 1. NUMBER OF YEARS BETWEEN CROPS IN ROTATION TO CONTROL DISEASES

Succeeding Crop \ Preceding Crop	Cereals	Corn	Buckwheat	Flax	(f) Rapeseed & Mustard	Sunflower	Alfalfa & Sweet Clover	Beans (dry)	Fababeans	Lentils	Peas (dry)	Potatoes
Cereals	(1)[a]	(1)[b]	e	-	-	-	-	-	-	-	-	-
Corn	(1)[b]	1[c]	-	-	-	-	-	-	-	-	-	-
Buckwheat	e	d	2	-	e	e	-	-	-	-	-	-
Flax	-	-	-	2	1	1	2	2	2	2	2	2
Rapeseed & Mustard	-	d	e	1	3[e]	3	1	1	1	1	1	1
Sunflower	-	d	e	1	4	4	2	2	2	2	2	4
Alfalfa & Sweet Clover	-	d	-	2	2	2	3	2	2	2	2	2
Beans (dry)	-	d	e	2	2	2	2	3	2	2	2	2
Fababeans	-	d	e	1	1	2	2	2	3	2	3	2
Lentils	e	d	e	2	2	2[e]	2	2	2	3	2	2
Peas (dry)	-	d	e	2	1	3	2	2	3	2	4	2
Potatoes	-	d	e	2	1	4	2	2	2	2	2	3

- Indicates that the crop can be seeded the following spring. Numeral indicates the number of years you should allow between crops to prevent disease problems.

a. Barley-wheat rotations are common. But some leaf-spot disease and common root rot could become a problem. If you see signs of these diseases during the growing year, break the barley-wheat rotation. Generally oats is a good alternate crop between other cereals. Avoid seeding oats in fields treated the previous year with Treflan or Avadex BW.

b. Corn after barley and wheat or vise versa could increase Head blight or Scab in barley or wheat and Gibberella stalk rot in corn.

c. One year between corn crops is desirable from a disease standpoint (stalk rot). If you use weed control chemicals with residual effect, you may wish to try continuous corn rotation.

d. Certain weed control chemicals used on corn can have short-term residual effect on crops following corn.

e. Volunteers from previous crops may cause crop competition and/or seed separation problems.

f. Heavy crop residue may be toxic to some crops following rapeseed in the rotation - thorough spreading of rapeseed straw prior to fall tillage is recommended.