

# Rotations For Sustainability

---



## **Partners:**

ACORN  
OACC  
NB Agricultural Council  
NS ACAAF Council  
PEI ADAPT Council and



Andy Hammermeister (OACC)  
Roger Henry (AAFC)  
Ted Zettel (Organic Meadow)



## Ecology – The Science of Connections

- *“In living nature , nothing is unconnected to the whole”*



## Human Health



- Healthy Animals:

- optimum nutrition
- minimum stress

- Healthy Plants

- Soil Health – Soil Life

plant community + livestock → fertility

tillage + rooting → structure

→ Soil Biology



The soil biological community can weigh from **1100 to 14000 kg/ha**; a similar weight as 2 to 28 yearling steers!

Over 1 billion microbes in 1 tsp of a fertile soil

## Managing Soil Life

- Eliminate biocides
- Balance minerals (not just NPK)
- Feed the soil with manure, compost, plowdown crops, good rotation

## Diversity

- Healthy soil requires a diverse plant community
- Many different species
- Many different types of plants
- Interplanting
- Weeds
- Crop rotation

# Rotations

---

- A planned sequence of crops grown to
  - sustain and promote soil quality while
  - reducing risks of insects, diseases, weeds
  - and buffer variability in climate or markets.



# Microbial Biomass

---

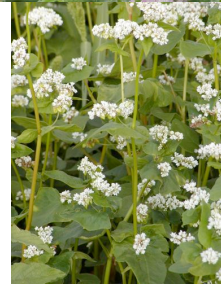
Nelson and Lynch, 2008

- Microbial biomass-C as a % of TOC was lowest in the potato year
- MBC/TOC increased to levels found under pasture (3.7% TOC) after two or more years



## Features of Rotations: Crop Nutrition

- Nitrogen fixing crops should alternate with crops with high N demand
- Apply manure or compost before heavy feeding crop
- Use a deep-rooted green manure crop to increase nutrient availability
- Match your crop choice with your fertility level (and climate)
- Use a catch crop to capture nitrogen after harvesting a heavy feeding crop or incorporating a legume
- Soil pH from 6.0-6.5



# Green Manure Crops

- Soil Improvement
  - Add organic matter
  - Protect soil from erosion
  - Improve soil structure
  - Break hardpans or compacted soil
  - Stimulate soil biology
- Nutrient Management
  - Add nutrients (esp. nitrogen)
  - Bring up nutrients from deep in the soil
  - Hold nutrients, prevent from leaching etc.
  - organic matter
- Pest Management
  - Smother weeds
  - Break pest cycles
  - Provide habitat for bees, parasitic wasps and other beneficial organisms



## Green manure crops in organic systems

- Cost
- Rotational fit
- Effect on soil moisture
- Soil and seedbed preferences
- Ease of incorporation
- Volunteers in the following crop
- Timing of incorporation
- Allelopathic effects
- Rooting system
- Rate of growth





# Green Manure Choices

- **N-fixation:**
  - Excellent: alfalfa, vetch, fava beans, soybeans
  - Moderate: clovers, field peas, birdsfoot trefoil
- **Adding Organic Matter :**  
Ryegrass, fall rye, oats
- **Break hardpans:**
  - oilradish,
  - sweetclover,
  - red clover,
  - lupins,
  - alfalfa
- **Ground cover:**
  - Ryegrass,
  - hairy vetch,
  - white clover
- **Weed control:**
  - Ryegrass,
  - buckwheat,
  - fall rye,
  - winter wheat,
  - oilradish,
  - mustard,
  - legumes (alfalfa, sweet clover, white clover once established)
- **Catch crops:**
  - Summer – buckwheat, ryegrass
  - Fall – oilradish, mustard, fall rye
- **Living Mulch:** white clover, ryegrass
- **Bee plants:** buckwheat, clovers, fava beans, sweet clover



# Features of Good Rotations: Soil Building

For maintaining soil organic matter and preventing soil erosion:

- Deep rooting crops should follow shallow rooting crops
- Crops of low root biomass crops with those of high root biomass
- Include perennial forage mixes
- Keep the soil covered in all seasons



<b>Common Cover Crops<sup>1</sup></b>	<b>Dry Matter Produced kg/ha</b>
Red Clover (plowdown)	2,700 - 4,500
Oats	1,000 - 5,500
Rye	1,000 - 4,000
Oilseed Radish	2,000 - 7,500

## Features of Good Rotations: Pest Management

---

For weed suppression

- Crops that develop slowly should follow weed suppressing crops
- Alternate leaf crops with straw crops
- Alternate between spring sown and winter sown crops
- Select crops that are competitive with weed problem

Avoid crops in sequence which host the same pests and diseases

Intercropping to increase crop competitiveness, compensate for variability in soil, and reduce disease and insect pressure (risk)





## Features of Good Rotations: Business Management

1. Balance machinery and labour by growing crops that spread out the timing of field operations
2. Grow money making crops in each year (i.e. make sure that the different fields are in different phases of the rotation)
3. Grow crops that are compatible with your equipment



## Rotation Checklist



Crops match soil type & pH	
Crops match soil fertility level	
Legumes in rotation before heavy feeder	
Soil builder before heavy feeder	
Manure/compost before heavy feeders	
Adequate break years for same crop	
Previous crop beneficial or neutral	
Soil always covered	
<50% of land spring seeded	

## Rotation example: Quebec Dairy Farm - 30 cows

- Forage (80 ac forage, inc. 40 for grazing)
  - Forage
  - Forage
  - Forage
  - Forage
    - Break after 1st cut
    - 2 months of weed (couch grass) control
    - Apply manure & lime
  - Spelt (20-30 ac, fall seeded for cash) or corn (10-12 ac) for feed
  - Mixed crop (30 ac) for feed underseeded to forage
- Critical success factors:
    - Optimize soil pH, drainage, land levelling
    - Forages for weed control and soil building
    - Roguing weeds in corn
    - Would like to add soybean
  - Grows short season corn



### Building a Rotation Farm type: stockless cash crop

**Objectives: sustainable, cash flow, fertility, biology**

Yr	Crop	Purpose	Suitability (preceeding and following crops)
1	Grass + legume	Inc. fertility, structure, erosion	Corn, wheat, soybean (light cereals for seed), strawberries
2	Corn + manure? (U/S?)	cash	Heavy
3	Wheat (u/s clover?)	cash	Med-heavy feeder, ++
4	Soybean	Cash, n-fixation	LIGHT, break disease
5	Oats (u/s clover	Cash/cover est. u/s	Med-light
6	Forages	Soil building	

## Building a Rotation

Farm type:

Objectives:

Yr	Crop	Purpose	Suitability (preceeding and following crops)
1			
2			
3			
4			
5			
6			

## Cash Crop Grains and Oilseeds

Note: N = compost/manure, > = second crop)

Yr	Field/Rotation A	Field/Rotation B	Field/Rotation C
1	Red clover	Soybean or Flax	Wheat
2	Red clover (1 cut, fallow) > spelt	(N) Wheat (u/s red clover)	Soybean
3	Spelt > <i>ann. rye</i>	Red clover	(N) Canola or Sunflower
4	Soybean OR Flax	Red clover (1 cut, fallow) > <i>ann. rye</i>	Barley (u/s red clover)
5	Hulless oats > <i>oil radish</i>	Canola or Sunflower	Red clover
6	Barley (u/s red clover)	(N) Corn > <i>ann. rye</i>	Red clover (1 cut, fallow) > <i>ann. rye</i>

## Quebec Grain Farm #2

- Forage (sold to dairy on same farm)
  - Forage
  - Forage
  - Sunflower
  - Corn
  - Soybean
  - Corn
  - Soybean
  - Wheat underseeded to forage
- Critical Success Factors:
    - Applied solid manure on corn and sunflower
    - Applied liquid manure on forage
    - Fall-applied manure for wheat
    - Plant early to optimize yield
    - Sunflower planting staggered for agritourism
    - 50% of farm income from sunflower oil (13000 L produced on 28 ha)
    - Timely weed control (tillage)
    - Grains swathed, dried



## Rotations

Note: Other management including weed control not shown (r. = red, w. = winter, f. = fall, N = compost/manure, + = intercrop, > = second crop) (Source: Organic Field Crop Handbook)

Year	Grain & Forage	Dairy & Cash Crop
1	W. Cereal + clover	W. Wheat > oil radish (N)
2	R. Clover	Oats + r. clover
3	Mixed cereal + forage (N)	Barley > f. rye (N)
4	Forage	F. Rye > Oil raddish (N)
5	Forage	Barley + forage
6	Forage (N)	Forage
7	Forage w. cereal	Forage
8		Forage > Spelt

## Rotations

**Note: Other management including weed control not shown (r. = red, w. = winter, f. = fall, N = compost/manure, + = intercrop, > = second crop) (Source: Organic Field Crop Handbook)**

Year	Cash Crop & Beef (Part A)	Cash Crop & Beef (Part B)
1	Field peas > oil radish	Corn + ryegrass <b>(N)</b>
2	Cereal + r. clover	Field peas > w. cereal
3	r. Clover > w. cereal <b>(N)</b>	w. Cereal + r. clover
4	w. cereal > buckwheat	Vegetables <b>(N)</b>
5		Faba beans + forage
6		Forage
7		Forage
8		Forage

### crop

- Spelt
- Oats
- Clover
- Corn
- Soybeans

### cover crop

- Oil radish
- Red clover
- Oats
- Min. tilled
- spelt

Crop	Over Winter
HAY	
HAY	
HAY	• RYE
RYE	• BUCKWHEAT
OATS	• VOLUNTEER OATS
BARLEY/OATS/PEAS	• UNDERSEEDED

CROP	OVER WINTER
• HAY	• WHEAT
• WHEAT	• RED CLOVER
• RED CLOVER	• OATS
• FIELD PEAS	• RYE
• RYE	• OIL RADISH
• OATS/BARLEY/PEAS	• UNDERSEEDED



## Crop Selection

---

- Select crops that best fit the timing in your rotation:
  - Heavy vs. light feeder
  - Cash crop, feed crop, soil builder
  - Previous crop: avoid disease risk
- Weed issues
- Timing of planting
- Risk:reward analysis (cost of production, potential return, risk analysis)
- Suitability for underseeding if needed



## Cultivar Selection

---

- Select cultivars that match your:
  - Fertility level
  - Seeding date  
late planting → shorter days to maturity
  - Crop heat units (CHU) available
  - Quality requirements
- Resistant to:
  - Insect
  - Diseases
  - Lodging
  - Winterkill
- Yield potential
- Suitable for underseeding if needed



## Seed Quality

---

- Seed purity: damaged seed, weeds, other materials
- Viability, germination, vigour
- Thousand kernel weight or test weight
- Disease presence
- Age
- Seed treatments
- Chemical treatments can reduce risk of various disease or insect problems
- Can promote mycorrhizal colonization of the crop roots
- Can promote the soil biology in the rhizosphere
- Inoculate legumes with appropriate Rhizobium, can increase yield by 30%



## Seeding Date

---

- Wheat, oats, barley, peas all well-adapted to cool conditions: Early planting generally recommended (as soon as can get on field)
- Can lose 10% of yield for every week you delay after field can be worked
- Early planting allows better harvest conditions
- Late planting can be used to allow preplant field operations for weed control or incorporation of manures, cover crops etc.
- Soybean should be planted in warm soils (15oC at midday)
- **IMPORTANT:** Delay planting at least 3 weeks after a ploughdown of sod or cover crops to allow decomposition of organic matter; else phytotoxins may inhibit growth



## Seeding Rate

---

- Adjust for thousand kernel weight (tkw)
- Increase if expecting high weed pressure
- Increase to promote uniform maturity and quality
- Increase if:
  - Expecting establishment losses
  - Germination
  - Vigour
  - Poor seedbed or seeder
  - Post-emergent mechanical weed control
- Target plant populations:
  - Spring wheat 300 - 400 plants/m<sup>2</sup>
  - Winter wheat 350 – 450 plants/m<sup>2</sup>
  - Barley 250 – 350 plants/m<sup>2</sup>
  - Oats 200-300 plants/m<sup>2</sup>



## Seeding Depth

---

- Cereals: plant at 2.5 cm depth, but tolerate up to 7.5 cm
- Small seeded crops: plant shallow (1-1.5 cm)
- Deeper planting delays emergence and reduces vigour of seedlings:
  - Increased susceptibility to diseases and pests
  - Reduced competitiveness with weeds
  - Uneven emergence and maturity
  - Deep planting bigger problem on cold/wet soils
  - Reduced yield
- Deeper allows:
  - Larger window for pre-emergent tillage
  - Planting into moisture (if soil dry)
- Do not plant soybean just before a cold rain!
- Plant shallow if soil is wet
- Winter cereal survival improved if planted at right depth



## Seedbed preparation for cereals

---

- Permit early planting
- Maintain or improve soil structure
- Destroy early weeds
- Permit uniform depth and placement of seed and fertilizer
- Provide conditions for rapid seed germination
- Seedbed temperature
- Straw management
- Evenness
- Clumpiness
- Stones
- Moisture content
- Firmness
- On heavy soils, may need to do preliminary tillage of cover crops in fall



## Seedbed preparation

---

- Level fields
- Reduce planting speeds to ensure uniform depth
- Plant into a firm seedbed and/or pack behind the seeder
- Good seed soil contact essential for rapid and even establishment
- Packing before planting:
  - Stimulates a flush of weeds
  - Creates a firm seedbed
  - Creates uniform and firm soil for fingerweeding
- Packing after planting:
  - Improves seed-soil contact
  - Can stimulate competitive weed growth (use a seeder that packs only in row)

