



Market Garden Crop Rotations

Facilitated by Ann Slater, Ecological Farmers Association of Ontario

The following workshop took place across the Maritimes in February 2008. In order to share the information that presented, notes were taken at each of the workshop and are now available. Please feel free to share this document with anyone who you think may be interested.

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Definitions:

“A Holistic Approach to farming considers the CONNECTIONS between all components within a farm and between the farm and the world. A holistic farming system maintains the ecological health of the land, water, air, people, plants and animals”
–EFAO February, 1992

Sustainability still doesn't have a 'simple little definition' because it is not a 'simple little concept'. But, being difficult to define doesn't make the concept of sustainability any less important. The most basic definition of sustainable agriculture is 'an agriculture that will last: an agriculture that can maintain its productivity and value to society, indefinitely.

“A sustainable agriculture must meet the needs of the people of the present, while leaving equal or better opportunities for those of the future.” –John Ikerd

Crop rotation is “The practice of alternating the annual crops grown in a specific field in a planned pattern or sequence so that the crops of a same species or family are not grown repeatedly without interruption on the same field”.
–US National Organic Program definition

OR leaving soil in the best position it can be for continuing/next crops – that includes cover crops, rotations, green manures, catch crops etc.

Why Rotate?

- Creates diversity
- Builds soil organic matter and provide nutrients
- Decreases weed
- Decreases pest and disease problems
- Provides economic value to the farm
- Make use of labour, equipment and knowledge on the farm

Creating Diversity:

- Include crops from a variety of plant families
- Use cover crops, ideally from different plant families during non-crop season's
- Plant mixture of cover crops such as legume and grass mixtures
- Inter-seed or under-seed cash crops with cover crops or green manures.

Builds soil organic matter and provide nutrients:

- Rotate soil-building crops with neutral and soil (nutrient)-depleting crops
- Include legumes in rotation
- Alternate crops with deep, intermediate and shallow roots to optimize access to nutrients and water and to cycle nutrients as well as cycle water
- Rotate low residue with high-residue crops (high-residue – leaves biomass on the ground – corn, sunflowers etc)
- Include crops with enhanced abilities to access nutrients
- Use cover crops, green manures and inter and under-seeding whenever possible
- Avoid bare soil (erosion and lose nutrients) by planting cover crops and leaving residue on the field
- Take land out of vegetable production on a regular basis-use it for pasture, cereal crops or legume cover crops
- Include cover crops and crops that stimulate soil biological activity (micro-organisms have feed source – keeping organic matter in the soil – don't kill them)

Decrease Weed, Pest and Disease Problems

- Alternating between warm and cold season crops
- Use cover crops to smother or discourage weeds, encourage beneficial insects and break disease and pest patterns
- Grow non-competitive (squash, radish, beans) crops after crops that compete crops after crops that compete well.
- Observe recommended planting intervals before planting crops from the same family
- Consider the following questions:
 - does this rotation include crops that can be marketed?
 - Are these crops likely to be profitable? (such as broccoli – on an acre and a half, broccoli takes up to much space even though it is a good seller – it is not profitable for small scale gardening)

- What are the marketing opportunities for these crops over the next few years?
- Does this rotation have the potential to provide ecological and income sustainability?
- What are the input costs?

Use of Labour, Equipment and Knowledge

- Questions to consider:
 - Do the crops in this rotation use equipment already on the farm?
 - Does this rotation consider time and labour demands for planting and harvesting?
 - Do I have the knowledge required to grow these crops?
 - Does this rotation allow for some flexibility, if needed (change in market demand, weather, availability)?

Challenges experienced in planning a rotation:

- Companion planting and crop rotation planning is complex
- Sticking to the plan
- Space
- How often you disturb the soil
- Perennials – how do you work them into a rotation
- Time – to plant, maintain and incorporate/harvest

Advantages of having a Standard Crop Rotation Plan:

- Easy for certification
- Knowledge of Crops
- Know what equipment you need long-term
- Easier to plan planting – don't have to re-invent the wheel every year
- Don't waste time making a plan every year
- Similar routine planning allows better evaluation of Farm planning and planting

Why have a multi-year rotation plan?

- Plan seed purchases and know your labour requirements
- Know your expenses and flow of expenses
- Rely on your experience – if it works keep going
- Preventative measures for weed and disease build-up
- You won't forget or make mistakes as easily if you have a *plan*
- Ease of documentation for certification
- Easier to calculate profitability – if you have a record of what you've done – it allows you to change or go back and better judge why things have gone off

Factors to consider for market garden crop rotation plan

- Biological Factors:
 - Easier to design and implement a plan with fewer crops
 - Botanical family – simple, useful rotation strategy
 - Part of crop harvested – root, fruit, leaf, grain
 - Growth habit of crop – vine, root, legume, leafy
 - Dense canopy versus open canopy
 - Companion planting
 - Diversity within the garden
 - Crop sequences that promote healthier crops
 - Livestock needs e.g. cover crop for forage or buckwheat for bees

- Nutrient/Soil Factors
 - Nutrient needs – requirements for crop
 - Nutrients available (compost, green manure)
 - Soil Factors – nutrient status, soil structure
 - Organic matter – amount of crop residue, use of compost, organic mulches, cover crops
 - Soil cover
 - Resting some land with forage/legumes
 - Affects of one crop on a subsequent crop
 - Ability to extract nutrients e.g. root depth, evolutionary status
 - Availability of equipment for plough down of cover crops, crop residues
 - Water needs
 - Soil type/soil variation
 - Cultivation/tillage practices
 - Use of living mulches
 - Vegetable growing may require seedbed preparation and/or harvest under wet soil conditions
 - Cereal crops can make a good break in a vegetable rotation by helping to build or maintain soil organic matter and soil structure
 - Risk of compaction
 - Risk of wind or water erosion
 - Access to manure to make compost

- Physical Layout Factors
 - Easier to design a rotation using fields of the same size or uniform strips or beds
 - Planting arrangement – raised bed, rows
 - Garden layout – e.g. need to keep tall and trellised plants to one area
 - Irrigation availability
 - Proximity to packing area and washing facilities
 - Microclimates in garden area e.g. South slopes, frost susceptibility, moisture retention
 - Amount of land needed for a particular crop – can vary widely

- Space to take garden out of market production and plant to cover crops/green manures
- Harvest set-up, e.g. need for tractors/truck lanes for heavy crops
- Timing Factors:
 - Timing of planting – early or late season, cool or warm season
 - Timing of harvest
 - Cover Crop plans
 - Succession planting – e.g. more than one crop in one year
 - Time management for farmer and staff
 - Spreading out risk
 - Perennial crops – need to plan ahead
- Pest Control Factors:
 - Break pest cycles
 - Weed management – cultivation/tillage practices, plastic mulches
 - Air flow between plants to cut down on fungal type diseases
 - Disease pressure
 - Attracting beneficial insects, birds
- Other Factors:
 - Demand for crop
 - Similar cultural practices – e.g. group crops needing irrigation or mulches.

Some General Patterns/Observations:

- Legumes, onions, lettuce and squash are generally beneficial preceding crops
- Potatoes yield well after corn
- Corn and beans are not affected by preceding crops
- Carrots, beets, brassicas are generally detrimental to subsequent crops
- Root crops (carrots, onions) do not compete well with weeds – for weed sensitive crops plan ahead at least two years
- Corn, potatoes, peas, squash tomatoes and the cabbage family tend to take a lot of space
- A crop rotation needs to be built around marketable crops – consider marketing plans
- Legumes, lettuce, and corn do not need a long time between crops
- The same root maggots can affect both carrots and brassicas
- A more ecological approach includes a long rotation and more use of cover crops, compost smother crops, mulches, allelopathy and crop residues
- Leafy crops can concentrate nitrites in low light conditions
- Excess nitrogen, especially in low light conditions, can contribute to aphid outbreaks
- Try to use crop sequences that help control weeds – e.g. row crops that permit mid-season cultivation and mowed or grazed sod crops help control annual weeds.
- Try to grow deep-rooted crops as part of the rotation

- Include legumes and soil building crops
- Try to include cover crops, green manures, intercropping or under-seeding
- Rotate competitive and non-competitive crops, especially to help with weed control

Planning a Rotation

1. Identify the Crops to be grown and the expected area
2. Group crops based on botanical family, production practices or other features.
3. Define the size of the rotational unit
4. Determine the land area needed for each grouping (# of rotational units).
5. Make a map of available land. Note features like size of field, location of rotational units, drainage, structures like deer fencing, weed problems
6. Start the puzzle of possible rotations. Consider biological factors, nutrient/soil factors, physical layout factors, timing factors and pest control.

*crop rotation unit is #/square metre etc...

Benefits of Cover Crops:

- Wind and/or water erosion control
- Hold Moisture
- Enhance organic matter
- Consider how it impacts next years crop
- Can also help dry out wet areas
- Tap root crops break-up subsoil, bring up nutrients
- Legumes – nitrogen fixing
- Trap crops for attracting insects
- Increases nutrient availability (example: buckwheat makes phosphorous more available)
- Provides a habitat for beneficial insects
- Provide mulches – living or mowed and dried next season
- Balances stress of production with soil building

Challenges of Including Cover Crops

- Time to plant
- Seeds – be careful to not let them become a weed!
- Find balance and timing – know when to plant what (what do you plant after late crops such as potatoes?)
- Required tools (grain drill for example)
- Cover crop is not an immediate cash crop – this takes space from market crops
- Potentially creating pest problems
- Too much residue
- Allelopathy

Cover Crop Options:

- Fallow cover crops that require taking land out of vegetable production for all or part of the season;
- Winter cover crops that are sown in late summer or early fall;
- Smother crops that are grown during a spring, summer or fall window between vegetable crops;
- Inter-seeded or under-seeded cover crops that are established while the vegetable crop is growing.

Allelopathy

Defined: “Suppression of one plant species by another through secretion of phytotoxins. These chemical compounds are produced while allelopathic crops are growing and/or decomposing”.

- Rye suppresses growth of other crops
- Buckwheat is detrimental to grass germination
- Oats
- Sunflowers

Transplants aren't as affected by allelopathic plants, but their growth can be slowed/stunted.

Questions to ask when decided on Cover Crops for your Farm:

- When is this crop planted and how easy is it to get established?
- Could it add organic matter to the soil?
- Does it fix or hold nutrients or make them more available? When is this crop planted and how easy is it to get established?
- Does it over-winter?
- How can it be controlled or worked back into the soil?
- Could it become a potential weed or create pest problems?
- Is the seed easily available and affordable?
- What kind of conditions does it need to grow well?

Alfalfa

- Location is really key in Atlantic Canada, as alfalfa needs loose soil
- Alfalfa has a very sensitive pH and doesn't like heavy wet soil.
- Can winterkill, but doesn't always
- Need equipment to incorporate alfalfa

Buckwheat:

- Aggressive smother crop – eliminates a lot of perennial weeds and grows fast
- Adds potassium to the soil
- Don't let it go to seed – it can be a hefty volunteer and become a weed problem
- As it grows so quickly, there is potential for several plantings
- Needs moisture to germinate
- Seed: readily available and the price is mid-range.

- Breaks down very quickly unless it's frozen
- Short season crop versatile – plant throughout season, but it does take a long time to establish in moist weather.
- It is frost sensitive; plant: late May/June through to August
- Stem can become quite woody – so buckwheat is better to incorporate when it's green (47 weeks).
- Buckwheat makes phosphorous more available by making areas around roots more acidic and thus it has a higher ability to incorporate phosphorous and calcium
- It will winterkill
- Big canopy but not a lot of mass
- Loosens soil
- Attracts beneficial insects
- Can grow in weak soil

Clovers

Sweet Clover

- Easy to establish
- Adds organic matter and fixes Nitrogen
- Easy and affordable to purchase
- Inoculants are useful for this crop for bacteria to fix Nitrogen

Red Clover

- Perennial
- Undressed with corn
- Red clover can be frost-seeded: with an early spring planting, it will stay dormant until germination
- How easy is it to incorporate? It is easy with plough – it does have a taproot: easier to incorporate with larger equipment
- Seed availability: readily available, especially in the triple mix, also works as under-seed
- Red clover is a deep-rooted plant and it increases soil organic matter
- Fixes Nitrogen
- Weed problems: if you let it go to seed it definitely volunteers – especially a problem in a small market garden.
- Seed is available at a reasonable cost
- Well-adapted to this Eastern Canada
- Approximately 8 weeks to seed; early incorporation means reduced nitrogen fixation, but if allowed to seed you will have volunteers.
- Tender perennial

Short Clovers

- Palestine, Egyptian and Strawberry varieties are supposed to be really low growing.

- NSOGA did trials with Egyptian clover and found that it was better than Crimson but most of the other varieties were not better than Crimson. Cost of seed may also be prohibitive for these other varieties.
- Annual clovers: our season for the most part isn't long enough to make good use of the annual clover varieties

White clover

- White clover is a great inter-seeded crop as it is shade tolerant. Inter-seeded with corn for example it is a great crop as it grows low to the ground. Great on pathways in between beds.
- Incorporating – doesn't have the red clover taproot– therefore it is easier to incorporate.
- White clover is the only clover that spreads and thus can be hard to control if it's not properly incorporated.
- It is a great green manure
- Seeds – stay with low grazing types – Dutch and New Zealand types.
- It is an early bolter – watch out!

Fava beans

- Hardy legume from Europe
- They are like field peas – germinate in cool wet ground – do better if planted a little later than peas however.
- Long crop – harvest in October/late September
- Grow with a small grain like oats or barley – this plant doesn't spread very well
- Great for biomass as the plants get very large
- Inoculated first year, high germination – grew well.
- Hard to turn it in as the stems get really thick
- Plough chopped up residue
- Not much of a weed – very obvious seed pods – you can use the beans – great for eating!
- Very mildew susceptible however.
- Vegetable seed variety is larger than the smaller cattle crop
- Nice for heavy land, clay soil seems to respond well
- Doesn't need a lot of fertility or lime
- They also offer food to beneficial insects early in the season
- Can feed beans and greens to livestock – they really enjoy Fava beans

Field Peas and Oats

- 80% / 20% ratio; by weight it's 50% peas/oats.
- Oats grow fast in spring and fall, so it's best to sow the oats a little later than the peas so they can be readily incorporated together. Otherwise, the oats get matty and woody and become more difficult to incorporate.
- This combination doesn't over-winter
- Oats do not decompose as well as peas
- Oats have more biomass

- Peas fix Nitrogen
- Oats will volunteer if they go to seed, peas won't volunteer however.
- Slug problems not uncommon as oats have such a high biomass.
- Peas are more expensive, but you use less and oats are cheap
- Pretty good for growing in a lot of different conditions
- Best to have it in before the end of September, as Nitrogen fixing happens only after a mature crop
- Have to make sure you pick the right variety so that you know that they'll mature at the same time.
- Make sure you're able to incorporate these crops – that you have the equipment is crucial!

Oilseed Radish

- Good Fall Cover Crop
- Can be planted in September, but should be planted in August, it winterkills.
- Absorbs nitrogen well from manure
- Easy to incorporate in following spring
- Not good to follow with Brassicae, as it is in the same family
- Best in cool conditions
- Doesn't generally become a weed
- Available and affordable
- Grows up to 2-4 feet high
- Deep root so can break up hard pan
- Small seed – use care while sowing for good coverage, need to cover it with soil after sowing.
- Nutrients – mobilizes phosphorous
- Easily tilled in the Spring
- Easily available, but not often grown in Eastern Canada
- Not shade tolerant
- Probably prefers cooler conditions, like brassicae.
- Good catch for liquid manure and regular manure

Rye Grass

- Annual often over-winters and perennial is not reliable, but it does a good job choking out weeds.
- Planting - Early spring to September, needs moisture. Plant late September for cover crop.
- Needs to be incorporated – spring and fall are ultimate time for incorporation. If it grows to long it can be difficult to incorporate. Rye grass is difficult to incorporate for intensive market gardeners without much equipment.
- Because of its allelopathic qualities, you should wait a minimum of two weeks before using the soil.
- Used often in pasture mixes because it's so aggressive in the spring – can be early harvested at the end of May.
- Annual – diploid and tetraploid – lentil variety is a good one: better plough down crop; there is a grazing type and a mowing type available.

- Seeding is easy, but needs good soil seed contact
- Needs nitrogen and moisture to grow well; can rob nitrogen, but can also be a great catch crop for excess nitrogen.
- Seed is available, but relatively expensive: recommended for full-season cover crop
- Good for organic matter to soil, fibrous thick stem and good root system

Vetch:

- Common perennial, with annual varieties.
- Perennial vetch is hard to get rid of once it's established.
- As it is a part of the pulse family, it is a good nitrogen fixer.
- Hairy vetch is an annual but can become a perennial depending on when its seeded. It is a better nitrogen fixer than common vetch.
- Green manure of choice in Eastern Canada.
- Chickling Vetch – AC GreenFix: Drought resistant, annual winterkills – 6 inches tall, like a tomato that suckers: high biomass therefore difficult to incorporate – it does winterkill at –8 degrees Celsius.
- Easy to seed but can be tough to get rid of!
- Common vetch now easier to find
- Hairy vetch difficult to find.

Karen Davidge, Good Spring Farm (NB), presented in Fredericton:

We started farming in the 1980's when there was not a lot of information accessible on crop rotations. Luckily, things have changed now, but we have learned a lot from our efforts of trial and error. My best and most reliable advice for you is “Plan for the unplanned.”

We started with 0.12 acres and gradually built up from there. We now have 5 acres in permanent pasture and 11 acres of crops in rotation. We also have a greenhouse (wood furnace with electric back-up) and we have planned rotations by the time of year: we start with early crops in greenhouse such as lettuces, greens. When they are harvested and cleared we plant the later, warmer varieties (such as tomatoes). This way, we get a full 8 months of production out of our greenhouse.

Some of the challenges we've faced have been “how to decide what grows where and when”? We have wet spots where we can plant a crop that will be ready to harvest when the ground has dried up sufficiently for planting crops. And then there are spots that are perfect for planting first thing in spring where we've learned that vetch, field peas and oats (cover crops that winterkill) are good – and the soil is prepped and ready to go come early planting time.

Things we advise you to consider that may affect your rotation planning: leased versus owned land, deer problems, ATV's, rocks for rock-free crops, top-soil plant requirements, weather: successive planting, field history and farm maps are critical.

Joyce Kelly, Nature's Route Farm (PE), presented in Charlottetown:

We grow Peas beans, cucumbers, beets, turnips squash, strawberries, rhubarb traditionally in the past, and this year we will also have asparagus, grapes and currants and other berries to diversify our market selection. We use cover crops and green manures as intensely as we can to keep our soil healthy and productive. We have some land that we have not yet even grown on yet, but we make sure that we have a healthy cover crop/fallow crop planted to keep the land in production.

We recommend that you plan to purchase a sickle-bar mower to cut green manures about to go to seed – it has been crucial for us sometimes.

For cover crops we grow buckwheat and oilseed radish mostly. We have sandy soil and we have a shale pit in the corner of our land. Oilseed radish seed is more expensive, but it has been really beneficial for our soils. This year, we simply mowed off the oilseed radish to keep the deep taproots in the ground – to loosen the soil and add organic matter. We've also found that winter wheat is a good fall crop.

We also grow and use hay for our compost which we mix with mussel mud, lobster leftovers from the lobster plant. In the past, we have also used sawdust and we are currently looking for manure sources. We use our compost heavily and we turn our compost piles every 4 or 5 days.

We use highway mix in between rows and we don't cut it between rows in the fall – this way we get good green manure. In the raspberry plants, we inter-seed buckwheat followed by barley. The buckwheat often volunteers, but it's not too much trouble as it's an easy weed to pull. We under-seed clover in the strawberry field so that it matures after the strawberry season – this way our strawberry field turns into a clover field – a great complement for the strawberries. We also plant either oats or barley between rows – we find it's better than buckwheat because they grow more quickly. Our rotation plan is by rows, to control pests, weeds and diseases – we plant mostly in long rows so this is very simple for us. Rows are best for mechanical weeders, as they need straight, measured rows to work. As soon as we pull a crop, we are sure to plant a cover within a week.

Rupert Jannasch, Avonmouth Farm (NS), presented in Truro and Kentville

My farm, called Avonmouth Farm, is located on the other side of Hantsport. The farm has been a family farm for over 100 years with sheep, cattle, pigs, and laying hens and thus in the past grew all kinds of grain and forage crops and other varieties of crops over the years as well. I have 15 arable acres that I've started to bring into production in the past 4 years.

Some advice: We tend to have acidic soils in Atlantic Canada, but organic farms are able to work with slightly lower levels of pH than in the conventional system. Once your system is working well organically with good bio-activity in the soil, the pH will work itself out. Many farmers forget about calcium however, an important soil mineral, I recommend Gypsum – it is good to apply sometimes for improving calcium levels.

Although I use moboard ploughing, I still advocate for minimal ploughing in organic farming – when I was younger I was heavily influenced by ploughman's folly where you should not turn your soil, but *mix* it. But, in the long run, I've discovered that ploughing can be quite useful and convenient. Organic systems don't like ploughing so much because we create plough-sole or a hard pan in soils – this works against organic systems because we want our plants to access deep soil for nutrients, where conventional farming works simply one foot under the ground. I try to compensate for any ploughing by using a sub-soiler (mine is quite small). The sub-soiler breaks down hard pan and loosens soil levels. The problem with this, is that it uses a lot of energy and effects don't last.

The real, organic answer is crop rotations and cover crops. I find oat crops are very reliable (under-seeded). I use sweet clover and other clover and timothy in second year. I like sweet clover because of its high biomass and it's very deep-rooted crop down to 6 feet into soil – they do a great job of breaking down the hard pan.

Sweet clover is a different family than normal red and white clover. In its growth it's similar to alfalfa – but the seed is much cheaper than alfalfa. It has a huge penetrating taproot that breaks up hard pans and brings up nutrients from deeper in the soil layers. This is how I compensate for ploughing. Over time, it's more economical to break it up this way. If you have a combine in the area, you can harvest the oats too! In the second year you want to leave sweet clover to grow as long as possible, but the biomass is intense and you have to have a plan to eventually cut it off. I mow it off with a disc mower and then I leave it to start to decompose and soften. Next, I use a bush mower to top it off. The best equipment would be a flail mower but I don't have one. Equipment is a very important consideration for what types of cover crops you want to grow.

Common Vetch is another good annual cover crop as it grows well in acid soils, has good biomass and root system and fixes a lot of nitrogen. You do have to be aware of how to mow it however, as it tends to tangles up mowers well – make sure you have found a good and effective way to incorporate it. You can also mow vetch several times, although I'm not sure if mowing affects the nitrogen fixation. Typically, vetch is fed to cattle, but it seems to me that with the frequent mowing, it could be used as a green manure.

You have to spend a lot of time planning rotations but it's not going to work all at once, it takes time to experience your system and know how to adjust the crops to your advantage.

High bush blueberries are a perennial crop, so I can't rotate. This means I have to work without the advantages of a rotation and so I've had to compensate as best I can for it. When planting the transplants, I went for the extreme range between rows, I planted raised beds, tilled sawdust in, and I have since applied aged horse manure with woodchips. I plant buckwheat in the background – fast growing, dense crop, great bee fodder – it's difficult though because once you see one flower, you've got tones of seeds and it will come up again and again.

Greenhouse rotations are difficult, especially because I have a tomato crop that I have been growing year after year, and I rely on my greenhouse alone to produce these tomatoes. I grow spinach with all of the transplants in the spring and then I plant all of my tomatoes. I don't really rotate crops in the greenhouse, I've thought about a green manure, but it's awkward and expensive to put a green manure in a green house. It would also be tricky to incorporate without being able to use the equipment.

I also use white fescue in my raspberry bed, it is really important to keep a weed free zone around the plants. I also try to use green clippings from mowing to mulch the cash crops. If you're doing this, you want to get it on in while it's green so be quick!