Crop Rotation, Disease Management & Brassicas
Crop Rotation

- “Is a fundamental practice of sustainable agriculture”—Vern
- “is a planned system of growing different kinds of crops in recurrent succession on the same land”—Vern
- “Most dependable agricultural practices are ages old. Crop rotation is a good example”—Elliot Coleman, *The New Organic Grower.*
  - The Greeks and the Chinese employed crop rotations
- “is worth 75% of everything else that might be done, including fertilization, tillage, and pest control” Elliot
- “In a word, crop rotation means variety, and variety gives stability to biological systems.” Elliot
Why Rotate?

- **Reduce pest pressure:**
  - Soil Borne diseases
  - Insect

- **Balance the availability of soil nutrients**

- **Improve the soil structure**

- **Reduce weed pressure**

- **Heavy feeders take advantage of previous grown legume with N.**

- **Light feeders follow heavy feeders**

- **Increase yields—SUM TOTAL of above**
Improve Soil Structure

- Different crops send roots to various depths allowing farmer to utilize the full depth of the soil.
- Nutrients mined by the deep rooters become available to the shallow rooters when residue is turned by into the soil.
- Different tillage practices lessen the impact upon the soil.
Monoculture encourages many soil borne diseases because the pest organisms specific to a crop can multiply out of all proportion when that crop is grown in the same place year after year.

Club Root in Brassicas requires a 7 year rotation

Many soil borne diseases winter over in the plant debris. If their host crop is no longer present their ability to survive is greatly reduced esp. over time.

Crops susceptible include

- Brassicas: Cabbage—you name it.
- Cucurbits: Pumpkins—White speck
- Legumes: Peas—root rots
- Solanaceae: Tomatoes—early blight
Insect Control

❖ Hinder insects that over-winter near the crop they infest
  • Colorado potato beetle
    ➢ **Walks into the crop**
  • European Corn Borer
    ➢ **Winters over in corn stubble**
  • Flea Beetles
    ➢ Brassicas—radishes

❖ Learn about the biology of the pest
Balance Nutrients

- Monocropping can deplete the soil of certain nutrients in disproportion to what will occur if crops are rotated.
- Levels of nutrients become imbalanced.
  - Subtle micronutrient removal will occur.
- According to Elliot rotations make nutrients more available.
  - Some plants are more effective in using less soluble forms of plant nutrients
    - The crop residues of these plants alfalfa, clovers, & cabbage will make the minerals more available to later less aggressive crops.
Reduce Weed Pressure

- Different crops mean different cultivation methods changing the way the weeds are impacted.
  - Different times of year that cultivation occurs may impact a certain weed at a certain time in its growth.
  - Some crops are cultivated so often they reduce the weed seed reservoir.
  - Some crops are simply clean cultivated.
  - Some crops are problem crops for weeds
    - Potatoes and melons for me
Heavy Feeders & Light Feeders

- Rotations allow for Heavy feeders like corn to follow a legume cover crop like Hairy Vetch or Alfalfa.
- Light feeders can follow heavy feeders

• Sum total Increase Yields and improved plant and soil health.
# Crop Features that may be the Basis for Rotation Groups

<table>
<thead>
<tr>
<th>Crop Features</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botanical Family</td>
<td>Crucifers, cucurbitis etc.</td>
</tr>
<tr>
<td>Harvested anatomical structure</td>
<td>Roots, fruits, leaves, or grain</td>
</tr>
<tr>
<td>Planting Arrangement</td>
<td>Multiple rows on raised beds, narrow single rows, or wide row spacing</td>
</tr>
<tr>
<td>Cultivation Practices</td>
<td>Hilled crops, basket-weeded crops, mulched crops</td>
</tr>
<tr>
<td>Timing of Planting and Harvest</td>
<td>Early, mid, late season; once over</td>
</tr>
<tr>
<td>Nutrient Demand</td>
<td>Heavy, medium, or light feeder</td>
</tr>
<tr>
<td>Cultural Practices</td>
<td>Drip irrigated, overhead irrigated, row covers applied</td>
</tr>
<tr>
<td>Pest Complex</td>
<td>Fenced for deer, sprayed for CPB, stale seedbeds used for weed control</td>
</tr>
</tbody>
</table>
Rotation by Botanical Family

- Simple, useful & practical
- Often members of the same family have many common issues:
  - Type of crop cool or warm season
  - Moisture demands
  - Pest problems—insect, disease, & other
  - Nutrient demands
  - Cultural practices:
    - Methods of planting
    - Cultivation techniques
    - Row covers
    - Frost control
<table>
<thead>
<tr>
<th>Botanical Classification</th>
<th>Family Name</th>
<th>Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amaryllidaceae</td>
<td>Lily</td>
<td>Garlic, onion</td>
</tr>
<tr>
<td>Chenopodiaceae</td>
<td>Beet</td>
<td>Beet, chard, spinach</td>
</tr>
<tr>
<td>Compositae</td>
<td>Lettuce</td>
<td>Endive, lettuce</td>
</tr>
<tr>
<td>Cruciferae</td>
<td>Crucifer</td>
<td>Broccoli, cabbage, kale, cauliflower, turnip</td>
</tr>
<tr>
<td>Cucurbitaceae</td>
<td>Cucurbit</td>
<td>Cucumber, muskmelon, pumpkin, squash</td>
</tr>
<tr>
<td>Gramineae</td>
<td>Grass</td>
<td>Sweet corn</td>
</tr>
<tr>
<td>Leguminosae</td>
<td>Legume</td>
<td>Bean, pea</td>
</tr>
<tr>
<td>Solanaceae</td>
<td>Nightshade</td>
<td>Tomato, pepper, eggplant, potato</td>
</tr>
<tr>
<td>Umbelliferae</td>
<td>Carrot</td>
<td>Carrot, parsnip, parsley, celery</td>
</tr>
</tbody>
</table>
Benefits of crop rotation widely recognized; not a lot of research or agreement on specific sequences of vegetable to optimize crop yields and health.

According to Elliot Coleman certain patterns emerge from studies:

- Beneficial Preceding Crops Include:
  - Legumes
  - Onions
  - Lettuces
  - Squashes

- Potatoes yield better after corn.
- Corn and Beans are not influenced in any detrimental way by the preceding crop.
- Carrots, beets and cabbages are generally detrimental to subsequent crops
<table>
<thead>
<tr>
<th>Crop</th>
<th>Rotation Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potatoes</td>
<td>Follow sweet corn because yields of potatoes benefit</td>
</tr>
<tr>
<td>Sweet Corn</td>
<td>Follows cabbage family b/c in contrast to many other crops, corn shows no yield decline when following brassicas. Also the cabbage family can be undersown with legume green manure which when turned under in spring provides ideal growing conditions for corn.</td>
</tr>
<tr>
<td>Brassicas</td>
<td>Follow peas b/c crop is finished August 1 allowing vigorous winter green manure crop to be established.</td>
</tr>
<tr>
<td>Peas</td>
<td>Follow tomatoes b/c they need an early seed bed; tomatoes can be undersown to a non-winter hardy green manure crop that provides no decomposition and regrowth problems in the spring.</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>Follow beans b/c this places them 4 years away from their cousin the potato.</td>
</tr>
<tr>
<td>Beans</td>
<td>Follow root crops b/c they are not know to be subject to the detrimental effect that certain root crops such as carrots &amp; beets may exert in the following year.</td>
</tr>
<tr>
<td>Root Crops</td>
<td>Follow squash and potatoes b/c they are good “cleaning” crops (kept weed free), thus easier to weed labor intensive root crops. Also, squash shown to be a beneficial preceding crop for root crops.</td>
</tr>
<tr>
<td>Squash</td>
<td>Is grown after potatoes in order to have the two “cleaning” crops back to back prior to the root crops, thus reducing weed pressure.</td>
</tr>
</tbody>
</table>
Vern’s thoughts on order of rotation

“The order of rotation among different crop families on many farms is usually planned without specific pest management reasons for deciding which crop follows another”.  
• Relies simply on diversity to protect against pests.

Production practices of each crop usually determine sequence of crops
• Field with heavy weed pressure, relatively competitive crop like corn and not root crops would be planted.
Tim’s Rotation Nightmare

I pick a beautiful sunny, quiet afternoon and motor out in my gator to the fields. I sit with my rotation maps in front of me, soaking in the late summer/early fall sun and contemplate, zen-like where next year’s crops should be located.

There is no master plan: Certain ! Criteria:

1. Start with ! Crop: Lettuce & Mesclun Greens $100,000
   a. Deer problem
   b. Early Southerly Exposed field for first 8 crops-get on early
   c. Fortunately these are the same fields by and large.
   d. Important to keep these fields weed free for mesclun weeding.

• Above criteria mean that Lettuce/Greens are alternated in a 2 year rotation with no apparent difficulties.
The nightmare continues

2. Switch to crops which require early dry soils:
   a. Peas, Early Potatoes, Root Crops,
      - Peas 4 year rotation sometimes difficult b/c need 10 times the space of either potatoes or root crops. **STUDY THE MAPS!**
      - Early Potatoes: move as physically far away from the preceding 2 years as possible. Make sure not locating where any other nightshades have been.
      - Root Crops: small space easy to find a place within the dry, southerly exposed soils to rotate 4 years.

3. Goal next is to find a 4 year rotation for all the rest of the crops.
   a. Brassicas looking for 5 year units—struggle
   b. Still moving from dry land to wetter land.
   c. Don’t want root crops where melons or potatoes have been.
   d. Often Lettuce and corn are rotated together—keep both very clean and very fertile. Corn supplies green manure for lettuce.
There is no master plan

1. Crops that need early, dry soils
2. Four year rotation
3. Lettuce and Corn usually 2 years.
4. Aware of Deer problems sites.
5. Aware of Woodchuck problem areas.
6. Rotations within rotations on certain pieces of land. (Behind Big Earth or Southerly exposed sites)
Fall Cover Crops

❖ Hairy Vetch:
  • Hardy, winter annual legume which if left to flower in the spring—end of May, will fix large amounts of N. Often seeded with oats or winter rye.

❖ Winter Rye:
  • Very hardy winter cover
  • Can be sown very late—early October.
  • Produces a lot of Bio-mass in the spring.
    ➢ Can be difficult to manage if in a hurry to plant.

❖ Oats:
  • Protects the soil for the winter
  • but winterkills permitting easier spring management.
<table>
<thead>
<tr>
<th>Year</th>
<th>Crop</th>
<th>Family</th>
<th>Production System</th>
<th>Subsequent Cover Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-3</td>
<td>Alfalfa Hay</td>
<td>Legume</td>
<td>Sod, three cuttings per year</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Sweet corn</td>
<td>Grass</td>
<td>30 inch rows, 5 cultivations</td>
<td>Winter rye</td>
</tr>
<tr>
<td>5</td>
<td>Squash, pumpkin</td>
<td>Cucurbit</td>
<td>8-foot rows, dead rye mulch</td>
<td>Inter seed ryegrass</td>
</tr>
<tr>
<td>6</td>
<td>Broccoli</td>
<td>Brassica</td>
<td>30 inch row, three cultivations</td>
<td>Inter-seed oats</td>
</tr>
<tr>
<td>7</td>
<td>Lettuce &amp; spinach</td>
<td>Lettuce &amp; beet</td>
<td>18-inch rows, raised beds, flamed stale seedbed</td>
<td>Winter rye</td>
</tr>
<tr>
<td>8</td>
<td>Tomato, pepper</td>
<td>Nightshade</td>
<td>30-inch rows, raised beds, plastic mulch</td>
<td>Winter rye</td>
</tr>
<tr>
<td>9</td>
<td>Onion &amp; carrot</td>
<td>Lily &amp; umbell</td>
<td>12-inch rows, raised beds, flamed stale seedbed</td>
<td>Winter rye</td>
</tr>
</tbody>
</table>
Brassica oleracea
Cole Crops

- Cabbage, Broccoli, Cauliflower, Brussels Sprouts, Collards, Kale, Kohlrabi = All members of the species *Brassica oleracea*.

- Collectively they are known as Cole crops
  - Cole from Latin caulis, meaning “stem” or “stalk”.
  - Very similar culturally and taxonomically
    - Much of what we discuss applies to all.
Cole Crops

- Cool season, hardy, dicotyledonous plants
- Origins along the maritime areas of Europe, including Mediterranean.
- Family name Cruciferae in Latin means “cross bearers”. The flowers have four sepals and four petals shaped in the form of a cross.
- “Functional Foods” = plants capable of synthesizing mustard oils and their possible relationship to “diet-based mammalian cancer chemoprotection.”
Plant Growth

- All cole crops prefer uniform cool temperatures. The optimum range for curd and head development is between 57-68F.
  - Above 68F quality is poor
  - Above 77F heads may not form

- These temperatures regimes explain why the highest quality crops are grown from mid-summer to late fall.
Cultural Practices

- **Seeding:**
  - 14 greenhouse seedings,
  - directly into flats by hand,
  - starting at the end of March until end of June.

- **Flats are stacked in the Greenhouse, with variable temperatures of 60-80F.**
  - Seeds germinate in about 5-6 days.

- **Grown on in Greenhouse for 3-4 weeks, some thinning and transplanting of misses.**
Hardening

- Placed in coldframe for a week to 10 days except cauliflower
  - Cauliflower is more difficult to grow. Sensitive to cold temperatures. Kept in greenhouse if very cold.
  - Transplants should not be older than 4-6 wks.
Transplanting

- Different machine than for lettuce or cucurbits.
- This machine pinches the stem of the plant and "gently" plants in in the ground.
- Spacing Rows 40 inches apart, plants 16 inches
- Walk the field afterwards straightening the plants
Role of Temperature in Head Formation

- Large, old transplants subjected to temperatures below 50°F may pass from vegetative growth into generative and produce smaller than normal heads—"Buttoning".

- Temperatures near 32°F may result in no head formation in cauliflower.

- High temperatures may cause the plant to regress into vegetative growth and cause bracts or small leaves to develop in the curd or head.

- High temperatures during curd development may result in loss of compactness and development of ricey curds.
Cultivar Selection very!

- **Cabbage:**
  - early not good for storage
  - Later varieties, excellent for storage
  - Size:
    - a lot supermarkets want small heads
    - Restaurants large heads for cole slaw

- **Broccoli:**
  - Careful with early varieties often subject to “buttoning”
  - Check the time of the season the variety matures.
    - May differ depending upon the time of year.
  - Choose carefully for disease resistance to head rot.

- **Cauliflower:**
  - Look for a dependable variety.
  - Be wary of the different colors.
Nutrient Requirements

- A heavy feeder compared to other crops:
  - 160 Lbs Nitrogen
  - pH of 6.0 – 6.8
  - Like Boron

- Manure at 20 tons per acre

- Broadcast 500 lbs of 4-10-10 with Boron.

- Sidedress 30-40 lbs N. during 2nd cultivation.
Cultivation

- Bat Wing Shovels 2 times: video
- No hoeing or hand weeding
- Inter-crop sowing of oats.
- Irrigation timely when heads are forming.
Too Wet!
Imported Cabbage Worm control with Bt biological insecticide
Disease

- Alternaria, Black rot, Black leg may be transmitted to the field by contaminated seeds. Seed is hot water treated (122°F for 25 minutes) usually by the seed supplier. Germination is often reduced.
- Cultivar selection eliminates most other problems
- Brown Beading individual buds abort under dry conditions
- Head rot caused by rapid growth and inability of plants to take up calcium due to poor transpiration rate during periods of wet, warm, humid weather.
- No control—mix varieties
Harvesting & Postharvest Handling

Cut, ice and store at 32°F.
Disease Management

❖ **KEY to effective disease management =**
  - **PREVENTION**
    - NOT TREATMENT
      - Often too late especially for those of us who do not like to spray.

❖ Managing Plant Diseases:
  - In order for pathogens to cause problems in a crop one of three conditions is require
    1) A susceptible host plant
    2) The presence of inoculum
    3) Conducive environmental conditions
A Susceptible Host Plant

- **Cultivar Selection that either shows:**
  - Disease Resistance = reduced susceptibility.
  - Disease Tolerance = ability to yield well in the presence of the pathogen.

- **Cultivar selection should be narrowed to the problem disease for our New England weather. May need to prioritize.**

- **Often there is no resistant or tolerant variety**
  BUT dramatic differences as to a varieties susceptibility often exist. Grower Observations.
Sanitation to Reduce Inoculum

Sanitation the CORNERSTONE of inoculum reduction.

• Farm is not a sterile place. Disease is always lurking. In fact it is part of the natural balance.
• Preventing the build up of inoculum aid in preventing an epidemic even with a susceptible host and favorable environmental conditions.
• Many Cultural Practices to reduce inoculum.
Cultural Practices

❖ **Clean Seed.**
  • Hot water treated seed: tomatoes
  • Fungicide-treated seed: sweet corn
  • Disease-tested certified: potatoes
  • Western-grown: beans

❖ **Transplant Production:**
  • Clean, sterile containers and growing structures.
  • Use sterile soil-less mixes
  • or if compost-based, alert for dampening-off
    ➢ **Optimum growing conditions and/or fungicides synthetic or biological.**
    ➢ **Example of organic practice clouding the issue.** (Desire for strong healthy organic transplants vs. sterile medium and less disease potential)
  • Good air movement and temperature control
  • Benches keep flats up off the ground (avoid soil borne pathogens).
Cultural Practices continued

- Roguing: removal or incorporation of isolated infected crops or crop residue can eliminate sporulation and spread of infectious agents.
- Prompt incorporation of crops at the end of the season helps reduce disease inoculum that has been building up as the season progresses.
  - Especially important for diseases that over-winter in undecomposed tissue.
- Power-washing tillage and other field equipment before moving it from one field to another.
- Avoid working fields leaves are wet.
- Wash hands after handling potentially infected plants.
- Air-blast sprayers may aid in spreading air-borne disease, especially bacterial pathogens.
- Exclude Insect Vectors that spread disease.
  - Pesticide
  - Barriers like row covers
  - Reflective mulch for aphid control
- Timely control of Weeds often a reservoir for disease.
- Maintenance of mowed areas around greenhouses and fields.
- CROP ROTATION reduces inoculum by not annually feeding the same pathogens in the soil and building up populations.
Cultural Practices which modify the growing environment of a crop in order to prevent the conditions that favor disease. Often they are the same as reducing the inoculum. See Table 16.2 in Vern/s book for complete list.

<table>
<thead>
<tr>
<th>Practice</th>
<th>Conditions Affected</th>
<th>Disease Prevented</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staking, Pruning, Wide-row spacing</td>
<td>Increase Air movement and leaf drying</td>
<td>Many foliar diseases.</td>
</tr>
<tr>
<td>Timely Irrigation, Drip vs. Sprinkler Irrigation</td>
<td>Minimize leaf wetness period</td>
<td>Many foliar diseases.</td>
</tr>
<tr>
<td>Windbreaks Boom vs. Air-blast sprayers</td>
<td>Limit spread of airborne spores</td>
<td>Many foliar diseases.</td>
</tr>
<tr>
<td>Optimize NPK fertility</td>
<td>Reduce stress, avoid rank growth</td>
<td>Diseases in general</td>
</tr>
<tr>
<td>Careful Cultivation</td>
<td>Promote healthy root growth</td>
<td>Many root and crown rots</td>
</tr>
<tr>
<td>Good weed control</td>
<td>Reduce source of inoculum</td>
<td>Many viruses</td>
</tr>
<tr>
<td>Rapid cooling at harvest</td>
<td>Slow microbial activity</td>
<td>Post harvest diseases.</td>
</tr>
</tbody>
</table>
Fungicides

- Must be used as long as weather and crop conditions are conducive to infection.
- Applied at or before the first sign of disease and reapplied at regular intervals.
- Good coverage is essential. Use spreader stickers, calm weather and appropriate nozzles.
- Software models exist for predicting disease development and need for fungicide application.
- Haphazard use of fungicide is usually ineffective and a waste of money. Need a Plan.