UBC Farm Crop Rotation Strategy Baseline

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Last update: January 2020

The UBC Farm is a 24-hectare academic farm situated within a 90-year-old coastal western hemlock forest. The UBC Farm comprises cultivated annual crop fields, perennial hedgerows and orchards, pasture, teaching gardens, and forest stands. All 24 hectares of the UBC Farm are organically managed, and UBC Farm produce is certified organic through North Okanagan Organic Association (NOOA). We cultivate over 200 varieties of fruits, vegetables, and herbs, and also feature honey beehives and egg-laying, open-pasture hens.

Why is crop rotation and the use of cover crops important?

Crop rotation is the practice of growing a diverse sequence of crop types in a field during successive seasons. In diversified agroecosystems, crop rotation plays a critical yet indirect role in facilitating soil fertility and microbial activity, improving soil physical properties, and minimizing occurrences of pest, disease, and weed problems (Roth, 1996; Rusinamhodzi, 2015). In contrast, monoculture, the practice of cultivating the same crop in the same area year after year, can deteriorate soil health and increase problems associated with pests, weeds, and diseases (Florentin et al., 2010).

Effective crop rotation strategies further impact crop production by increasing soil nutrient availability for crops, enabling farmers to use fewer inputs, and increasing crop yields compared to monoculture methods (Roth, 1996; Frick and Johnson, 2002). Additionally, the inclusion of crop rotation practices helps to increase the level of in-farm crop diversification. Crop diversification, known as the practice of cultivating various crops with unique characteristics and production timelines, allows farmers to spread out production activities over the course of a growing season, provide consistent work to field staff, and avoid costs associated with poorly-timed planting and harvesting (Roth, 1996). Incorporating crop rotation into farm's production strategy can thus decrease the costs of production and increase profits.

The cultivation of cover crops, also called "green manures", is a key element of organic farming that has many potential benefits: reducing soil erosion, improving soil structure, adding nutrients and organic matter to the soil, reducing nutrient leaching, and recycling nitrogen and other nutrients that have already been leached to deeper soil layers (Florentin et al., 2010). Cover crops are planted during times of the year when growing food crops is not feasible due to climatic or production constraints. They are an essential component of a successful crop rotation strategy. See summary of benefits from cover crops grown at the UBC Farm in Table 1.

The combination of crop rotations and cover crops into cropping systems has been shown to increase soil infiltration, reduce soil erosion, increased soil fertility, reduced susceptibility to pests and disease, and increased crop yields compared with conventional methods (Thierfelder et al., 2012).

Table 1: Services and function of winter cover crops used at UBC Farm. Cover crop functions extracted from Mohler *et al.* (2009) and Florentin *et al.(* 2010).

Cover Crop	Crop Function
Rye	• High biomass production abundance residue for green manure • Effectively supresses weeds and pests • Attracts beneficial insects • Grows rapidly, even in cold conditions • Captures unused soil nitrogen, enhances water infiltration, and increases concentration of exchangeable potassium at top of soil profile via extensive fibrous root system
Legumes	• Symbiotic relationship between crop and bacteria in soil facilitates root nodule development and catalyzes biological nitrogen fixation • Stimulates growth and activity of soil microbes • Effectively suppresses weeds • Many species are tolerant of drought and cold
Ryegrass	• Builds soil structure and enhances water infiltration and water-holding capacity via extensive shallow root system • Reduces nitrate leaching during the winter • Effectively suppresses weeds and facilitates early-season weed management • Helps reduce insect pest levels • Provides abundant forage for livestock • Tolerates flooding once established

Crop rotation strategy at UBC Farm

The UBC Farm practices an eight-year crop rotation cycle, in which the same sequence of grouped crops is continuously repeated in each *field block*. For this crop rotation, crops are grouped in six *crop rotation groups* based on cultivation strategy (e.g., plastic mulched beds, tractor mounted sweeps, etc.), crop timing, market demand, irrigation needs, disease susceptibility, and spatial needs. *Crop rotation groups* include *Alliums and Legumes*, *Brassicas*, *Cucurbits* (*late* and *early cucurbits*), *Goosefoots*, *Nightshades,* and one plot for egg laying open pasture *chickens* which is also accounted as a "crop" group within the rotation strategy. See crops included in each group in Table 2. Each year, a *crop group* is assigned to a *field* block where it is grown for that year. Next year, at the same production field, the following *crop group* of the *crop rotation sequence* will be grown (Figure 1).

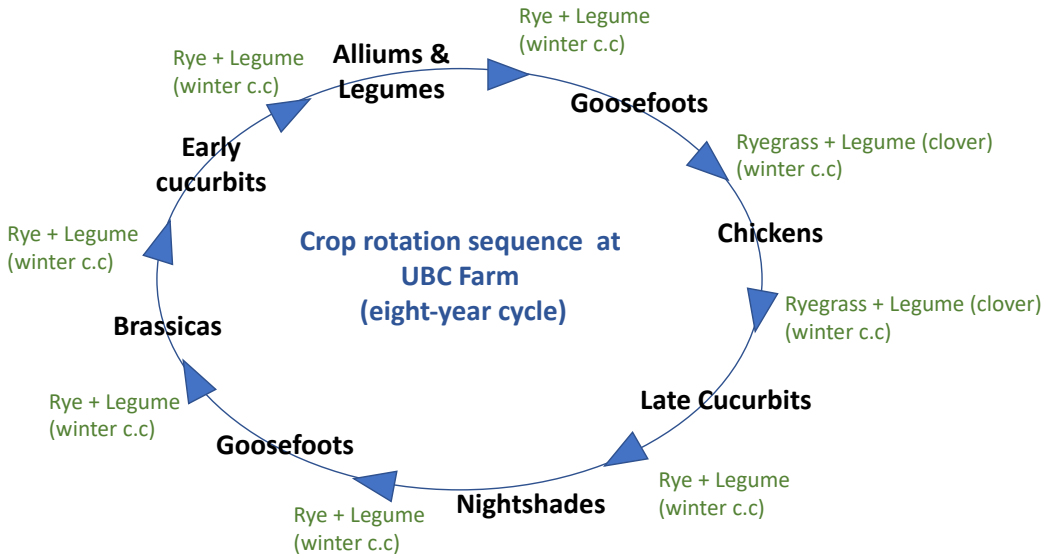

Figure 1. Crop Rotation sequence at UBC Farm seen as an eight-year cycle. Winter c.c., represents winter cover crops (in green).

Based on this *crop rotation sequence*, Cucurbits and Goosefoots have a four-year rotation at the field block level, while Alliums and Legumes, Nightshades, Chickens, and Brassicas have an eight-year rotation. We particularly limit our production of brassicas to an eight-year rotation with the intention of limiting the spread of clubroot at the Farm and preserving our ability to grow some high-value brassicas.

Cover crops used at the Farm are rye, legumes (clover, winter peas, or hairy vetch), and ryegrass. They are planted in the fall following their crop rotation group as shown in Table 2

and included in the crop rotation sequence (Figure 1). Most of the *crop rotation groups* are followed by a combination of rye and one or two legumes. Only before and after the chicken rotation, an alternative cover crop, including ryegrass and clover, is grown in the respective field block.

Table 2: Rotation crop groups, winter crops and other crop cultivation details (irrigation type, bed width, number of rows per bed) for UBC Farm crop rotation strategy. Asterisks indicate the timing of some specific winter cover crops.

Crop Rotation groups	Grouped crops	Winter cover crop*	Irrigation type	Bed width (in)	Rows per bed
Alliums and Legumes	Garlic, Leek, Onion, Snap Bean, Pea, Fava, Edamame	Rye + Legume	Drip	44	1 and 2
Brassicas	Salad Leaf Brassica Broccoli & Cauliflower, Cabbage, Collard & Kale, Kohlrabi, Radish & Turnip	Rye + Legume	Sprinkle	44	2 and 3
Chickens	NA	Ryegrass + Legume (clover)	Sprinkle	NA	NA
Cucurbits (Early and Late)	Early cucurbits: Cucumber, Summer Squash, early Winter Squash Late cucurbits: Pumpkin, late Winter Squash	Rye + Legume	Drip	88	1
Goosefoots**	Beet, Carrot, Celery & Celeriac, Lettuce, Chard, Chicory, Fennel, Annual Herbs, Spinach	Rye + Legume or Ryegrass + Legume*** (clover)	Sprinkle	44	2 and 3
Nightshades	Tomato, Pepper, Potato	Rye, Legume	Drip	44	1 and 2

*Cover crops planted in the fall after each crop rotation group
** Note that Goosefoots crop group includes many crops historically categorized as goosefoots (Genus *Chenopodium*) as spinach, beets, and chard, but it also includes vegetable asters and umbels such as lettuce and carrots.
*** Ryegrass + Legume (clover) is planted after Goosefoots when followed by chickens

This Farm crop rotation strategy occurs throughout eight equal-area (1,955 m^2) *field blocks at the Farm* (Figure 2*)*. Crop rotation groups are assigned to the field blocks in a paired system, so two *paired crop groups* are assigned to physically contiguous field blocks whenever possible. *Paired crop groups* are: Early Cucurbits with Late Cucurbits, Chickens with Brassicas, Alliums and Legumes with Nightshades, and Goosefoots which are annually planted in two contiguous production fields. Keeping *paired crop groups* together from one year to the next is necessary to maintain a four-year minimum separation between crops of the same family at the field

block level. Within this system, after each four-year period, the paired crop groups within each pair of field blocks switch fields and proceed through another rotation.

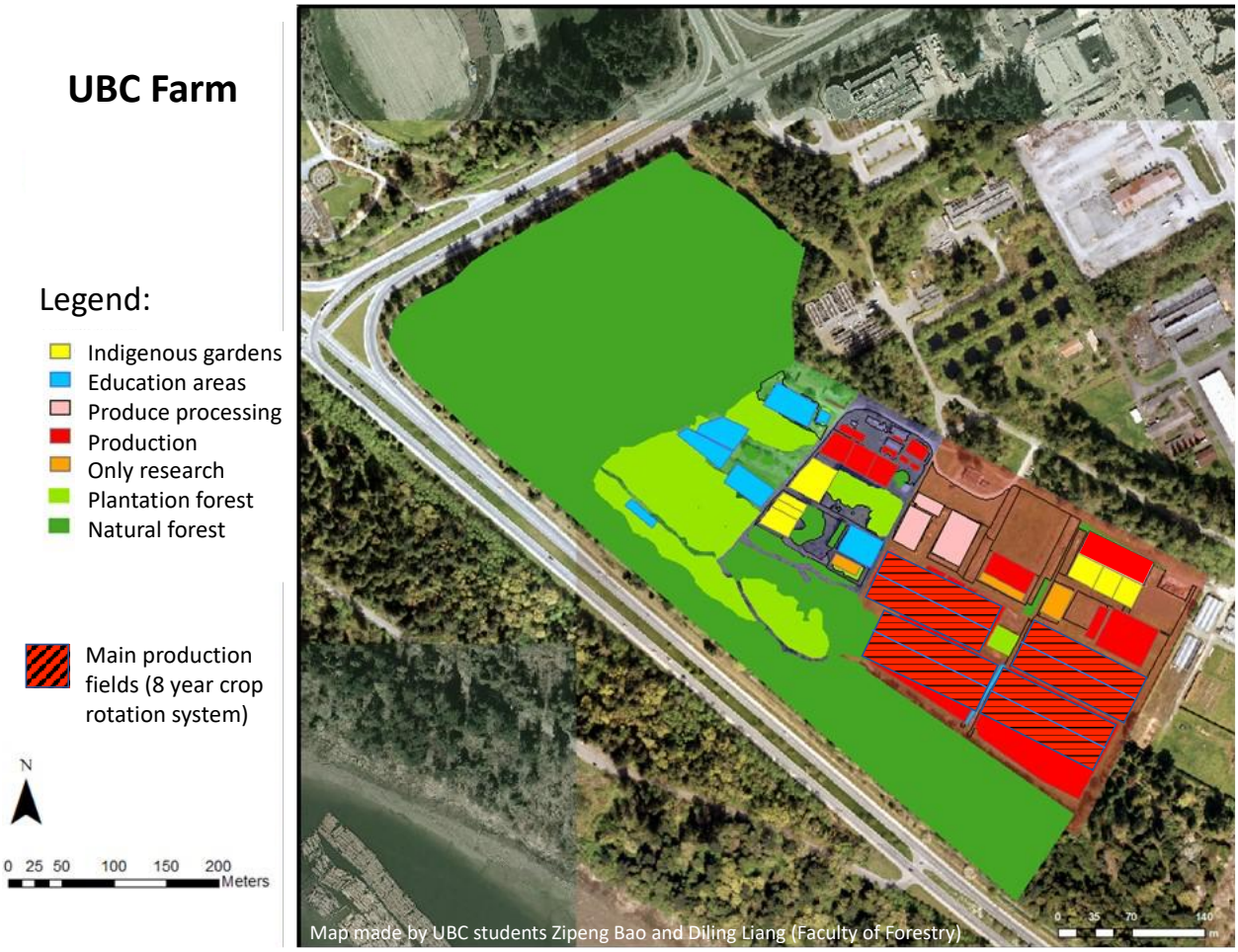

Figure 2: UBC Farm map showing the main crop production fields at UBC Farm involved in the eight-year crop rotation strategy.

Over time, strategic amendments to the current crop rotation plan have resulted from issues such as disease susceptibility, pest management, and shifting market demands. Table 3 summarizes major changes made to the system since 2010.

This crop rotation strategy is a reference system. Rather than being a rigid guide, it is used as a tool for informed decision making within a dynamic system. When changes are needed from this theoretical crop rotation system due to unexpected challenges (i.e., pests, seed supply limitations, etc.), our field team considers a number of variables including disease susceptibility, crop nutrient requirements, compatibility of irrigation strategies among crops (such as drip or sprinkle), and previous winter cover crops used at field level. It is also important to consider that this crop rotation strategy is implemented in the eight core field blocks of the Farm (~1.6

ha). The rest of the non-core field blocks at the Farm are treated in a more flexible fashion to allow specific experimental activities which do not always align with the Farm's general eight-year crop rotation strategy. These fields act as swing spaces to buffer disruptions in the crop rotation strategy on the core field blocks as shown in Table 3. In those non-core field blocks, a minimum four-year rotation at the field block level for all the crop rotation groups has been enforced as an alternative to maintain minimum crop rotation practices. For further questions about the UBC Farm crop rotation system, please contact the UBC Farm manager (tim.carter@ubc.ca).

Table 3. Chronology of changes made to the UBC Farm crop rotation strategy since 2010 with reasoning.

Year	Change	Reasoning
2010	• Consolidation of two previously separated crop rotation groups, Large Brassicas and Small Brassicas, into one unique group, Brassicas. • Decreased number of crop varieties in large Brassica group. • Goosefoots expanded to fill in gap in number of Brassica types.	Concerns about the spread of clubroot, a common disease of brassicas, caused by Plasmodiophora brassicae (Phytomyxea group)
2012	Production of potatoes (a nightshade crop) starts and they are grouped within the alliums to become the "Alliums & Nightshades" current crop rotation group	High wireworm levels had prevented this previously
2014	Corn crop (originally grouped with Alliums) is discontinued and therefore removed from the crop rotation strategy	Production of corn is relatively unprofitable at this scale and in this climate
2014	Shuffled several crops around to better align with irrigation strategies	Mitigate issue of overhead irrigation in Brassica field causing undesirable late-season drift onto Alliums & Potatoes group, potentially exacerbating fungal problems on these crops
2019	Added tomato and pepper tunnels to our crop rotation (forming the new Nightshade group together with potatoes). Also moved alliums (which had previously been in a group with potatoes) into a new group with legumes.	Adoption of a new crop protection technology (3-season caterpillar tunnels) made the incorporation of tomatoes and peppers into our field crop rotation a possibility. Since tomatoes and peppers are nightshades, it made sense to pair them with potatoes. This resulted in a need for a new crop rotation group for alliums. Conveniently, we also wanted to reduce the field area devoted to legumes due to the fact that they are a relatively unprofitable crop. Hence the new pairing: Alliums & Legumes.

Records of crop rotation and cover cropping practices at the UBC Farm are documented in our operations datasets. These datasets are publicly released annually through the CSFS Dataverse repository, as open-access data that can be used for academic research and accessed by farmers and the general public. As a certified organic Farm, UBC Farm submits all details about our annual cover crops and crop rotation strategy to the NOOA annually to renew our Organic Certification.

References

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