

Orchard Alley Cropping Demonstration Establishment & Management brief

Updated September, 2024

1. Background

Productive agroforestry is a set of agricultural technologies and practices that integrate trees and other forms of agricultural production in the same space, resulting in multifunctional agroecosystems that can produce diverse crops and support a greater degree of biodiversity and ecosystem services than annual or perennial monocultures. Productive agroforestry in an alley cropping design involves fruit and nut production in rows with complimentary uses of the understory and alleys for hay, annual crops, herbaceous perennials, shrubs, and/or animal grazing. Generally, the complexity of management increases with the number of intercropped species and vegetation layers, representing tradeoffs in efficiency, diversity, and total food production in the system. Best management practices for satisfying different goals (such as carbon storage, protein production, total food production, biodiversity, early cashflow, nutritional diversity) while maintaining manageable and harvestable orchards have yet to be established for the Pacific Northwest.

This document is intended to provide documentation and discussion of management during the development of the Gilber Rd. Orchard Alley Cropping Demonstration over its first season (2023-2024)

2. Project goals and design, year 1

This project aims to establish a productive agroforestry demonstration site by adding alley crops to the existing orchard site of the Gilbert Road farm. This alley crop is designed to satisfy several system goals:

1. Nutritional diversity – supplementing the micronutrient and sugar content of fruit production with micronutrient content from storage vegetables (cabbage, winter squash) and protein, starch, and fat from pulse and small grain staple crops. The alley crop has been planned for a three year crop rotation.
2. Demonstrating transition from orchard floor to alley crop production using no or low-till methods.
3. Demonstrating alley crop production using a range of management intensities.

	Alley 1 (Veg 1)	Alley 2 (Veg 2)	Alley 3 (Pulse/grain 1)	Alley 4 (Pulse/grain 2)	Alley 5 (Pulse/grain 3)	Alley 6 (Pulse/grain 4)
system goal	Micro-nutrient diversity, early cashflow	Micro-nutrient diversity, early cashflow	Staple food production, early cashflow	Staple food production, early cashflow	Staple food production, early cashflow	Staple food production, early cashflow

Year 1 crops	cabbage	squash	flax	Dry beans	Dry beans	Dry beans
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3. Management, year 1

Overview

- Site prep: Installation of black plastic mulch in 7-foot wide alleys (fall 2023, winter 2023-24)
- Pruning: Significant lowering & renovation of pear canopies for improved airflow, light-penetration, and to renew fruit-bearing surface (winter 2024)
- Alley crop planting: Cabbages were transplanted and squashes were transplanted and seeded directly into residue after black plastic removal. Flax was sowed using the Jang seeder without tilling, but after raking of residue. Beans were sowed using the Earthway seeder after shallow tilling (spring 2024).
- Weed management & cultivation: various strategies, including old-fashioned hoeing (cabbages, flax), pre-emergent flame-weeding and mechanical cultivation with a wheel-hoe (beans), hand-weeding (mostly thistles and dandelions, all alleys) and regular mowing (all alleys). See details below on weed management challenges and solutions. (spring-summer 2024).

Site Prep, fall 2023

West orchard – The first stage of bed prep was carried out August 30 2023. The orchard was mowed with a low deck on August 25th. Then, on Aug 30 (following a heavy rain the day before), 2 alleys were prepped for solarisation, 4 alleys were prepped for overwinter smothering, and one alley was left mowed but uncovered.

For overwinter smothering, we cut lengths of black plastic sheet into 7 foot width strips, placed down the centre of the alleys and weighed them down with clods of soil+sod.

For solarization, we prepared two trenches down the centre of each alley, 6 feet apart with the rotary tiller, throwing the loose soil outward toward the tree rows. We then spread ~ 7 foot wide clear plastic sheets over the middle of the alley, tucking the sheet edges into the trenches and covering with soil and cut grass to firmly “tuck in”. Solarized alleys were monitored over the following two weeks.

Unfortunately, we didn’t get enough hot weather and the sod kill was incomplete, with fresh green growth in places. We therefore removed the clear sheets and put down black sheets for overwinter smothering as for the other alleys on September 18th.

Pruning, winter 2024

Pruning of both the West and East orchard took place over Jan-Feb 2024. As the orchards had been intermittently pruned previously, resulting in excessive vigour and wood high up in the trees, beginning a process of significant canopy rebuilding was necessary.

For the pears, there was no consistent tree structure throughout the orchard so the number of leaders was selected on a per-tree basis (ranging from 1 to 4). Additional/competing leaders were removed. If leaders were missing, where possible, we chose an upright shoot as a “new” leader; these upright

shoots were topped (to encourage more upright growth) and marked with neon tape. The interior of the tree was cleared of branches. Most other upright growth was removed, unless branches were in good locations, and could be positioned (with weights or positioners) for lateral growth in the spring. Remaining branches were 1) thinned 2) ends were singled out and 3) shortened (stiffened up).

For the cherries in the West orchard, we followed a similar process, but because the canopies were so high, we did the big cuts with a chainsaw. After choosing leaders, we likewise thinned, singled out, and stiffened up remaining branches. In some trees, main branches were entirely cut off and new growth was left to rebuild structure and renew fruit bearing surface.

Grafting and new plantings, early spring 2024

West orchard – Bosc pear scions were grafted onto two existing rootstocks; one using whip and tongue, one using a cleft graft. Of these, one successfully leafed out (the whip and tongue graft). Three new Bosc trees and two new Liberty apple trees were planted in formerly empty spaces. The trees were all bare-root trees from Dinter’s nursery on Vancouver Island.

East orchard – Cherry scions cut from the existing orchard were grafted onto three existing rootstocks (1 using a cleft graft, 2 using a bark graft). While these grafts budded out, they then failed, resulting in no successful grafts.

One new cherry tree, and four new plum trees were planted, two of which were destroyed in an accident with machinery, resulting in just three new trees in the whole East orchard. The trees were all bare-root trees from Dinter’s nursery on Vancouver Island.

Alley crop prep and planting, spring 2024

Establishing alley cropping in the West orchard was generally intended to be a no or low-till transition (see initial steps in the Site Prep section above). However, we had to adapt to specific conditions and challenges, both with preparation and crop choice. The original plan, and what we ended up doing for the first year of transition to alley cropping in the West orchard is summarized in the table below.

	Alley 1 (Veg 1)	Alley 2 (Veg 2)	Alley 3 (Pulse/grain 1)	Alley 4 (Pulse/grain 2)	Alley 5 (Pulse/grain 3)	Alley 6 (Pulse/grain 4)
system goal	Micro-nutrient diversity, early cashflow	Micro-nutrient diversity, early cashflow	Staple food production, early cashflow	Staple food production, early cashflow	Staple food production, early cashflow	Staple food production, carbon storage
Prep (as planned)	Solarization (summer) -cover crop (fall/winter) -crimping (spring)	Solarization (summer) -cover crop (fall/winter) -crimping (spring)	Black plastic (summer, fall, winter)	Black plastic (summer, fall, winter)	Black plastic (summer, fall, winter)	Black plastic (summer, fall, winter)
Prep (actual)	Solarization failed; Black	Solarization failed; Black	Black plastic (fall, winter)	Black plastic (fall, winter)	Black plastic (fall, winter)	Black plastic (fall, winter)

	plastic applied over fall, winter	plastic applied over fall, winter				
yr. 1 crops (as planned)	-brassica (spring, summer) -cover crop (fall, winter)	-squash (spring, summer) -cover crop (fall, winter)	-flax (spring, summer) -multi-species cover (fall, winter)	-buckwheat (spring, summer) -multispecies cover (fall, winter)	-oat (spring, summer) -multispecies cover (fall, winter)	-kernza (perennial)
Year 1 crops (actual)	cabbage (spring, summer)	squash (spring, summer)	flax (spring, summer)	Dry beans	Dry beans	Dry beans

Preparation, planting, and replanting

After a fall and winter under heavy black plastic, the sod-kill was good, barring a few small areas where the mulch had been blown or torn.

On April 18th, plastic mulch was removed from all of the alleys, except for Veg 2 (this alley was intended to be for squash, which would be planted later). Soil was firm and springy, soft enough to plant into with a trowel.

On the same day (April 18th) Cabbage seedlings were transplanted into Alley 1, with three plants across the width of the row at 1.5 foot spacing. Dead grass was left in place as mulch. Golden flax seeds were sown into Alley 3 using the Jang seeder in 5 close parallel rows down the length of the alley. Dead grass was raked aside so that the Jang seeder could operate (though it still got gummed up with grass and had to be unclogged periodically).

Harvest

Cabbage was harvested from early July through September. Plants were left in place to see if we could get a harvest from a second cut (which we did, though small).

Flax was harvested on September 6th. It was pulled out, bundled with elastics, and roots trimmed. Bundles were placed in large paper bags to catch any shattering seed capsules, and hung to dry indoors.

Squash were all harvested on September 6th. They were placed in a shaded greenhouse to cure for two weeks.

Beans were harvested on September 6th-13th. Pods that were at the leathery stage (i.e. could be easily bent without snapping) were pulled off the plants and laid out to dry on tables in a greenhouse. For

beans that were mature enough, but not sufficiently dry, we pulled the entire plant and hung them in bundles in the greenhouse to complete the senescence process.

See harvest data sheet [harvest log, 2024.xlsx](#) for data

Table 2: Alley crop yields, year 1

Crop	Benchmark yield for BC (tonnes/hectare)	Benchmark yield other (tonnes/hectare)	Yield year 1 (saleable) (tonnes/hectare)	Yield year 1 including discard (tonnes/hectare)
Cabbage	19.2 ¹	26.2 ²	23	31
Winter squash & pumpkin	26.8 (pumpkin only) ³	15-40 ⁴	15.5	15.5
Flax	2.08 ⁵	1.1-1.5 ⁶	.83	.83
Dry bean	2.4 ⁷	1-3.5 ⁸	1.3 (Cranberry/Taylor horticultural) .83 (Jacob's cattle bean) .8 (Black turtle) .99 (average)	.99

Yields for year 1 for cabbage and winter squash were within BC and Canadian benchmark ranges (table 2). For cabbage, the actual edible/saleable yield was significantly lower than the total yield because we didn't harvest consistently throughout the season and failed to protect the crop from cabbage moth and slugs resulting in a large amount of discard. Despite this, our yield was greater than the BC average and comparable to the Canadian average. For winter squash, we did not experience any spoilage, but slug damage to germinating seeds was significant leading to a lower planting density than would be ideal. Our yield was on the lower side of benchmark yields for BC and elsewhere in Canada, though these vary quite significantly depending on variety, and would be higher to "Halloween" type pumpkins that are

¹ Area, production and farm gate value of field vegetables British Columbia, 2012-2022. [B.C. agriculture and seafood statistics publications - Province of British Columbia \(gov.bc.ca\)](#)

² Canada-wide average yield for 2003; Crop Profile for Cabbage and Broccoli in Canada - https://publications.gc.ca/collections/collection_2009/agr/A118-10-9-2005E.pdf

³ *ibid*. This yield is for pumpkin only, mostly consisting of "halloween" pumpkins rather than winter squash grown for consumption.

⁴ Squash and Pumpkins - Vegetable crops production guide for the Atlantic provinces, <https://www.gov.nl.ca/ffa/files/agrifoods-plants-pdf-squash-pumpkins.pdf>

⁵ Grains, oilseeds and other field crops: Production 2013-2023 - [B.C. agriculture and seafood statistics publications - Province of British Columbia \(gov.bc.ca\)](#)

⁶ [Quality of western Canadian flaxseed 2023 \(grainscanada.gc.ca\)](#)

⁷ [Grains, oilseeds and other field crops: Production 2013-2023 B.C. agriculture and seafood statistics publications - Province of British Columbia \(gov.bc.ca\)](#)

⁸ Beans (Dry) - Vegetable crops production guide for the Atlantic provinces [Beans \(Dry\) \(gov.nl.ca\)](#)

not grown primarily for culinary use. We grew a medley of varieties that included sugar pumpkin, kabocha, red kuri, french heritage varieties, delicata, and others.

For flax, our yield was less than half of the reported benchmark yield for BC, and about 30% less than the 2023 average yield for all of Western Canada⁶. Thus, it isn't clear if our yield was affected by shading from the pear rows or by management issues that are more easily addressed. Further trials are needed to determine this.

For dry beans, we grew three types. The yield for one of them (Taylor Horticultural) was within the expected yield range according to a production guide from Atlantic Canada, but lower than the BC benchmark yield. The other two varieties were about 20% below the lower range of the expected yield, but well below the BC benchmark yield from the BC Ministry of Agriculture. Because of significant variation between bean varieties, it is not clear if the lower yields are due to shading, management issues, or simply lower yielding heritage varieties. Further trials are needed to determine this.

Bed prep for fall/winter

Due to staffing issues, we decided not to install cover crops and instead re-tarp all 6 rows. Cover crops would be best to use for rows where transplants are planned for the following year. Tarping would be better in general for direct-seeded crops.

4. Pasture to production transition challenges

(or, we made these mistakes so that you don't have to)

Late clear plastic installation: We installed the clear plastic over our first two alleys at the very end of August 2023, intending them to heat up and kill the sod and seeds (solarization). But we had already missed the hot summer weather, and the alleys never heated up enough to achieve this, instead providing a nice, warm, greenhouse effect for the groundcover plants. We had to remove the clear plastic and replace it with black over the winter, like the other alleys. Solutions: If you intend to solarize, plan to do it during a long enough period of hot weather.

Premature plastic mulch removal: We planted the cabbages and sowed the flax on the same day that plastic mulch was removed, allowing them to establish before germinating weeds began to dominate the alleys. The alleys that were uncovered, but only planted into buckwheat and oats a few weeks later ended up failing to establish well, as they couldn't compete well with the already-germinating weeds, resulting in these alleys needing to be shallowly tilled and re-seeded with something else. Solutions: Taking steps to reduce the timeframe between plastic removal and planting would have greatly improved our crop outcomes. Alternatively, if the planting area must be exposed to the environment for a period prior to planting some form of pre-planting cultivation would make a significant difference: options include shallow cultivation, flame weeding, or an organic herbicide.

Sod kill, not seed kill: While the black plastic mulch over the fall and winter did a good job killing the thick sod covering the orchard floor, we did not get enough heat during this time to kill weed seeds. As a

result, all the alleys that were uncovered experienced copious germination of young weeds of all kinds, including grasses growing from seed. This weed competition was especially problematic when we didn't plant immediately after uncovering the rows. Solutions: Besides old-fashioned weeding and hoeing (which we did a fair amount of), other strategies, if well timed, can reduce weed pressure with less labour. Pre-planting and/or pre-emergent cultivation would make a significant difference: options include shallow cultivation (wheel hoes, basket weeder, finger weeder), flame weeding, or an organic herbicide. Taking steps to reduce the timeframe between plastic removal and planting would have greatly improved our crop outcomes.

Perennial weeds: Some weeds, such as thistle and dandelion are perennials that store significant carbohydrates in their roots. They will re-sprout from the thick taproot once uncovered and continue to re-grow throughout the season. Solutions: depending on your scale and how big of a problem these weeds are, they can simply be uprooted with a trowel. Keeping up with these weeds is ongoing throughout the season.

Slug habitat heaven: Establishing alleys for crops between rows of trees means that (unless you are maintaining a bare-ground orchard), the alley crops will be close to grassy orchard floor edges on both sides. Long grass is a great habitat for slugs. Our cabbages, young beans, and young squash plants sustained significant damage from slugs despite good germination, resulting in the need to replant some areas. Solutions: Mow frequently and as accurately as possible along the edges of your alleys to keep grass short and prevent encroachment and overhang from the orchard floor into the alley. A power-ox type cultivator with crescent hoe set at the edge would also be a good solution, if available. Transplanting squash seedlings rather than direct seeding would have mitigated slug issues for that crop. If slug pressure remains high and cultural controls have been exhausted organic slug bait products are available on the market.

Planting into non-tilled soil: Planting transplants or large seeds (like winter squash seeds) into non-tilled soil is easy, just use a trowel for transplants or easily push seeds in by hand. For crops with smaller and more densely planted seeds, using a mechanical seeder such as a Jang or Earthway seeder can require a bit of finesse, as these seeders are typically used on fluffy, recently cultivated soil. Solutions: For these seeders to work, leftover residue from the dead sod must be raked aside so that the wheels don't jam, and the soil must be moist and yielding enough to allow the furrowing mechanism of the seeder to work. Plan to remove residue and test your seeder, or plan to do transplants and large-seeded crops that can be easily planted through residue into soil that isn't broken up.

Cultivation of non-tilled soil: Most mechanical and even motorized equipment for small and medium scale agriculture is designed for tilled soil. Soil that has not been tilled cannot easily be hoed with a wheel hoe, as the soil aggregate is not broken up, and is more of a solid, springy surface. Even using a walk-behind tractor with a power-harrow over untilled soil that still had some dead sod residues on the surface was difficult due to constant clogging. Solutions: This will always be a challenge in any transition from perennial to annual systems, especially with established sod layers. Growers can improve outcomes with a longer period of tarping and rest, perhaps an extra season, to allow more of the sod layer to break down.

5. Scaling up alley cropping for BC orchards

Explanation of assumptions of analysis

- Base production unit area of 5 acres
- Tree Spacing
- Rows per alley

This economic analysis of the scalability of alley cropping in B.C. orchards presents potential costs and returns for alley crop production within 5 acres of tree fruit orchards. Our analysis is based on the trials outlined in this document. The alleys in our orchard system were (X) wide and each included one row per alley.

Based on our data collected in the 2024 season we are assuming that the orchard interference is minimal and as such we are using baseline yield calculations for B.C.

The proposed orchard is a semi dwarf apple orchard. The row spacing is 14' between rows. Rows are 250' long. There are 62 rows in the orchard. The growing area per row is 3' wide and accounts for 750 sq ft of bedspace per row. This represents 46,500 Sq ft of bed space in the 5-acre orchard.

<https://wpcdn.web.wsu.edu/extension/uploads/sites/25/EM092E-Commercial-dry-bean-publication.pdf>

Economic Analysis

Yield potential

- Capital purchases for non orchard equipment
- Variable costs (seed, fertility, packaging)
- Labour needs and timing
- Infrastructure needs (PHH, irrigation, equipment)

Identify return/cost year over year, and place these against infrastructure upgrades. Tiller, crimper, drill, . To pay for cabbage, it will take X years.

Add some extra labour and tractor (20%) to account for going between rows/ edge effects

Totals: now your 5 acre orchard is making x per year instead of Y per year. Possibly more even labour use – sharing budget fixed costs for more enterprises.

6. Reflections and discussion

The first year of establishment of a diversified alley-cropping system poses both conceptual and practical management questions that need to be resolved.

Concept and design

Conceptually, landowners/farmers need to decide what system goals they have, and what design and crop choices will support that. Our goal for the alley crop in the West orchard was nutritional diversity, with a specific emphasis on storage vegetables and high-protein small grains and pulses. One of our original system goals was also to demonstrate alleys on a range of management intensities, using one of the alleys for a perennial grain crop (Kernza) and one for a diversified hay crop. However, these two goals had to be put aside (at least for this season). The first, due to a lack of available seed, and the second, due to realizing that that final alley was needed for movement of vehicles and equipment, and that we do not have access to a seed drill that would allow for no-till planting of a new pasture mix. We also ended up changing the crops in two additional rows due to poor establishment of our intended year 1 crops, and replacing them with dry beans, which were originally intended as a year 2 crop. Thus, while the general layout of the alley crop remained as planned, we adjusted the crop plan that would still be consistent with some of our system goals around nutrition.

Our system goal, to demonstrate the range of management intensities for an alley crop, may need to wait until 1) we have better seed availability for Kernza; and 2) we have no-till seed drill infrastructure.

In the East orchard, our system goal was to establish a woody perennial polyculture with high fruit & nut diversity that would demonstrate a range of better and lesser-known tree & shrub crops suited to the Richmond area. This goal remains, but we simply didn't have the budget to implement much of it during this first season.

Management and practical challenges

On a practical level, we encountered weed and germination challenges that required pivoting from a 100% no-till approach to a mixed approach where shallow tillage was used on 3 of the 6 alleys after the initial plantings on them failed to establish. (see section 4 above). We also did a round of flame weeding, and more hand-weeding than initially anticipated. Such challenges should be expected during the first several years of transition from sod/pasture/orchard floor to alley crop production. Adapting to them with a range of tools and practices appropriate to the scale of production is necessary.

Automated equipment for our small research scale

- [Eden No-Till Seed Drill - Earth Tools](#)

- [Manual Crimper-Roller - Earth Tools](#)

Yield and productivity

Overall, our annual alley crop yields, which fall within the benchmarks yields for BC and Canada for cabbages and winter squash demonstrate that the crops we chose grew well between the rows of pear trees, even with no fertility amendments during year 1, less than ideal pest management, and other management challenges linked to transition from orchard floor to production. Even better yields would be expected as the system is fine-tuned, but as a basic observation, fertility and light do not appear to be a major limiting factor in this alley cropping system.

We did not record tree fruit yields for year 1 due to a failure to treat for pear scab resulting in an insignificant harvest. This will be necessary to assess overall yield and nutritional diversity and productivity from the system.

Considerations for adoption of alley cropping systems in BC

Needs

- Infrastructure requirement for different systems. Irrigation, machinery, Post harvest handling
- Skills / knowledge needed
- Market for goods
- Labour for production

Possible benefits/ why consider adoption?

- Labour flows for the farms – what type of labour is needed when for the cropping options and how does it complement with farms typical labour
- Split fixed costs over more enterprises
- Reduced costs from less mowing?
- Potential IPM outcomes?