



Community Supported Agriculture (CSA) Production Manual of the Organic Farming Unit at the University of Kentucky

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Kristi Durbin completed this work in fulfillment of a master's degree of science in integrated plant and soil science. She has worked as the University of Kentucky Community Supported Agriculture (UK-CSA) manager since February 2016. All information gathered for this project was the result of documenting production practices and improvements made since the program's inception.

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Executive Summary

The University of Kentucky Community Supported Agriculture program (UK-CSA), located at the Organic Farming Unit (OFU) of the UK Horticulture Research Farm, has been developing since its inception in 2007. The UK-CSA exists for education, extension, and research, in keeping with the land-grant mission of the university. The farm is one of the only land-grant university teaching farms that is also a commercially productive farm.

The direct marketing model of CSA has risen in popularity over the past three decades. The first CSA programs started in the United States in 1986.¹ Nearly thirty years later, the USDA census reported 7,398 CSA programs in the United States.² In Kentucky alone, there are 104 CSA programs tabulated as Kentucky Proud.³ Agricultural producers entering into the CSA model are expected to have a broad foundational knowledge of annual vegetable production systems. CSA farmers need the skills to provide a consistent supply of diverse, high-quality fruits, herbs, and vegetables for members, which includes knowing how to successfully grow, harvest, process, store, and market over 30 to 40 different crops. This document provides a foundation for CSA producers to learn about farming for a CSA program, from the vantage point of a mechanized CSA production model for 250 members located in central Kentucky.

This manual provides benchmarking for new and established operations; tips for production efficiency; the framework adopted at UK-CSA to run a CSA; and tools that can be adapted and customized to other farms. The tools in this document include templates for planning CSA shares and executing field plans; calendars for keeping production on target; and a fertility planner.

In addition, this manual provides a crop handbook for growing crops for a CSA model. The handbook is the primary resource for daily UK-CSA operations, as it provides a detailed look at how to produce crops in bare ground, plasticulture, and biointensive systems. The handbook outlines best practices for crop management; harvest and post-harvest handling protocols; guidelines for food safety; crop storage requirements; and packaging recommendations. This handbook is a versatile reference for beginning and experienced farmers alike.

Lastly, the manual includes examples of the UK-CSA's standard operating procedures (SOPs) for on-farm management and various production components.

The entire manual can be adapted and tailored to another farm, and it serves as a cornerstone of the Apprenticeship for Sustainable Agriculture course at UK (SAG397) and the UK-CSA hired workforce. This manual is a teaching tool for students, staff, and future farm workers alike.

Previous publications discuss the UK-CSA system. Therefore, this document discusses the updates and additions to the UK-CSA production system since the publication of Economic Analysis of the University of Kentucky Community Supported Agriculture Organic Vegetable Production System (SR-111).⁴ In addition, this guidance will be updated to match our system as it undergoes changes. This manual shares a comprehensive, multifaceted tour of the UK-CSA system that can inform and guide a wide audience of growers at different scales and varying levels of experience.

UK-CSA Farming System

CSA Overview

The University of Kentucky's Horticulture Research Farm is managed by the Horticulture Department in the College of Agriculture, Food, and Environment.

The University Farm is located on the unceded ancestral lands of the Hopewell, Adena, Yuchi, Shawnee, Cherokee, and Osage peoples.

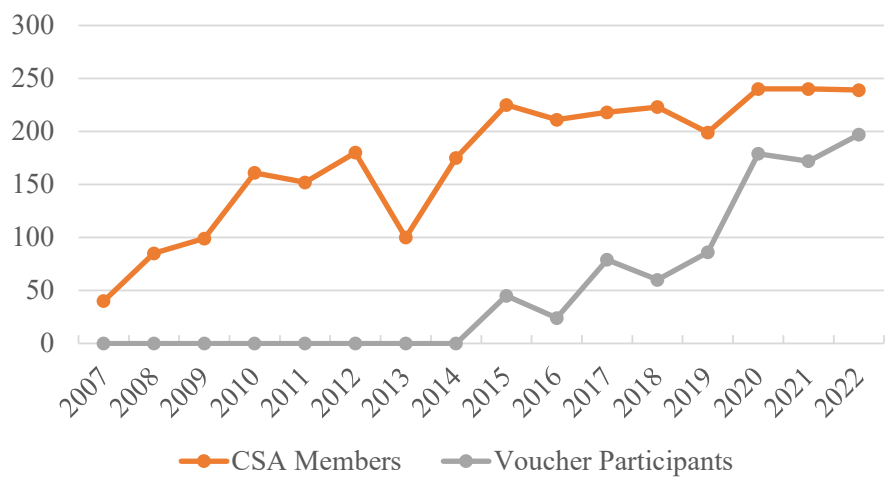
A historic farm developed on these lands, which grew hemp and raised horses, until ultimately it came under the ownership and oversight of the Commonwealth's flagship university. This farm has been under the management of the university since the mid-1900s for horticultural research, extension, and education. This 100-acre farm in southern Fayette County houses the OFU, comprising 35 acres of USDA-certified organic land. At the OFU, the UK-CSA program began on a quarter of an acre in 2007, and as of 2021, it manages 10-12 acres for 250 members.

The genesis of the OFU began as a response to the tobacco buyout.⁵ With tobacco buyout funds, the OFU began to explore the possibility of organic vegetable production as an alternative to tobacco. The intended demographic was already endowed with land, equipment, infrastructure, and some farming expertise. Thus, from the beginning, the goal of the OFU and CSA programs was to develop a profitable,



Figure 1. The Organic Farming Unit at the Horticulture Research Farm.

Table 1. UK-CSA membership and voucher trends, 2007-2022.



mid-sized, mechanized, and diversified farming production system. This end goal helped to steer the decision-making process about how the OFU and CSA programs would evolve over time, from scale to equipment acquisition.

At the start, the CSA was an exploration of the agricultural possibilities for growers across the state in a post-tobacco landscape. Yet this extension-focused purpose was not its sole aim; the CSA has always been a keystone in the formation of an undergraduate degree curriculum in sustainable agriculture and community food systems. As a part of this degree program, students take a 3.0 credit-hour class, Apprenticeship in Sustainable Agriculture, at the OFU, which involves weekly classes and practicum on-farm during the growing season. The UK-CSA strives to be an exemplar of the tripartite focus of sustainable agriculture: environmental stewardship, economic profitability, and social responsibility.

When the CSA began in 2007, there were only 40 shares. Over 15 seasons, membership grew to 250 shares. Over 130 students have completed the apprenticeship in this time. In 2015, the UK-CSA was one of the founding members of the Kentucky Farm Share Coalition, which launched a subsidized voucher program for CSA shares. The Health and Wellness group at the University of Kentucky has piloted this program by offering \$200 off the cost of a CSA share as a taxable benefit to UK employees on a health care plan. The voucher recipients represent a portion of total CSA membership. A total of 645 vouchers have been distributed over seven seasons, totaling \$129,000 of savings to UK-CSA members.

The CSA is not a student farm; the program is managed with five full-time equivalent (FTE) staff. In order to have consistent production that overlaps with the academic calendar, the CSA needed its own dedicated staff. The goal of economic sustainability also guided this decision, and the full economic analysis can be viewed online.⁶

CSA Model

The hallmark of CSA is variety. The foundation of UK-CSA shares is vegetables. The shares consist of six to 12 different items every week, and the shares are sized to feed approximately four people.

For planning purposes, crops are divided into several categories. The goal for planning CSA shares is to include in each week's share a mix of items that check off as many of these categories as possible for peak variety. These categories are divided as follows: staples, greens, storage, herbs and fruits, specialty items, and other items.

Staples are defined as the tried-and-true vegetables that are crowd-pleasers. These are the crops that everyone will gladly eat, and most members will have the acquired cultural knowledge of how to prepare them with minimal guidance. At UK-CSA, staple crops include broccoli, carrots, green beans, lettuce, sweet corn, tomatoes, peppers, summer squash, and cucumbers.

Greens encompass those items that are generally eaten fresh and for which the shelf life is not as long. Green items include arugula, bok choy, braising greens, cabbage, collards, kale, napa cabbage, salad greens, spinach, and Swiss chard.

Storage crops include roots, tubers, and shelf-stable crops like winter squash that can be stored longer and distributed on a more flexible schedule. The crops that fall into the category of roots and tubers include beets, radishes, rutabagas, potatoes, pumpkins, sweet potatoes, turnips, and winter squash.

Herbs and fruits diversify CSA share offerings. UK-CSA shares include annual fruits, like watermelon and cantaloupe, and one perennial fruit, rhubarb. Herbs in this category include basil, celery, cilantro, dill, garlic, green onion, and onion, as well as occasional perennial and biennial herbs like oregano, parsley, sage, and thyme.

Specialty items are those that are not as familiar to CSA members. These are also crops that tend to be harder to produce within the main season or are more labor-intensive; therefore, from a farming perspective, these items are not ideally included in shares each week—or even every year. However, they play an important role in teaching farmers how to grow something new and introducing CSA members to new crops and flavors. Crops in this category have included artichokes, brussels sprouts, cauliflower, dry beans, edamame, eggplant, fennel, ginger, hot peppers, kohlrabi, leeks, okra, popcorn, snap peas, snow peas, and turmeric.

CSA Planning

The [Share and Field Planner](#) workbook is used to project CSA shares and schedule their associated field seedings or plantings. To plan for 22 weeks of the diverse CSA shares that members expect, every crop is designated to be given out for a specific week (or multiple weeks) during the season. The end product becomes the starting point for planning and is developed in the worksheet [Projected Shares](#). There are certain parameters that guide these decisions of the projected weekly shares.

First, the timing of planting and harvesting is considered. Planting calendars for Kentucky are checked.⁷ Since the farm is located in central Kentucky, in zone 6b, winter temperatures fall to -5°F on average, and the frost-free period starts around April 20 and ends around October 21. This information informs when certain frost-sensitive crops can and cannot be planted outside. Historical data is referenced to help make accurate predictions for which crops can be reliably harvested at different times of the year. These dates are used to double-check that the projected shares match climatic parameters.

Second, single-harvest crops are differentiated from cut-and-come-again crops in the planting plan. With cut-and-come-again crops (like kale or lettuce mix) or successively harvested crops (like summer squash and cucumbers), the goal is to get as many high-quality harvests as possible from a single planting without overwhelming members with the same items. Single-harvest items and storage crops (like cabbage and head lettuce) are easier to stagger over nonconsecutive weeks.

Third, the goals for CSA box variety aim to supply crops that check as many categories as possible in each week. Some crops (the staples) are included frequently, while others (the specialty items) are included infrequently.

Fourth, some crops are grouped together in a week's share for member advantages. For example, UK-CSA always grows leeks for shares, but members only receive them one or two times per year. Some members are unfamiliar with leeks but may be familiar with leek and potato soup. Therefore, leeks are frequently paired with potatoes for one of the midsummer boxes. As a second example, when tomatoes start coming in strong, some hot peppers are also included with the tomatoes, as a tomato bounty is a prime excuse to make salsa.

The worksheet [Target CSA Variety and Timing](#) incorporates these considerations for planned shares and is referenced during the entire planning phase. Once the [Projected Shares](#) worksheet is completed, the [Crop Plan](#) worksheet can be developed with details for each item, from seed orders to harvest. This spreadsheet is a critical component of the planning process.

The [Crop Plan](#) worksheet can be used to calculate how many row feet of the crop should be planted for the CSA share. The share calculation method relies on predictable yield values on a per-row-foot basis. Each season, yield values are revisited and adjusted as needed. Yield values are not replaced entirely each season, as inconsistencies in yield may occur in different years and with different crop varieties; therefore, average values are used. The average value is calculated based on the value used in the planning process the prior year and the actual yield data tabulated for that year, as calculated on the [Harvest Log](#) worksheet. For example, with green beans,

the crop yield through 2019 had been averaged at 0.29 pounds per row foot . The actual yield in 2020 for green beans was 0.35 pounds per row foot. Averaging these two values gives a projected yield of 0.32 pounds per row foot going into the next season.

Here are a few rules of thumb to consider in the planning process:

- A 25 CSA-member buffer is added to the plans to account for crop loss or underperformance. In addition, this buffer amount is not wasted, as any surplus can be sold retail through another marketing channel.
- Common sense still informs the decision-making process. If the yield data calculates that only 1.7 rows of a crop are needed to be planted for the CSA, it is more practical to round up to two rows. It is not realistic to plant such precise amounts, especially on a larger scale.
- A buffer for seedling loss in the greenhouse or inexact row measurements in the field is always given. For the greenhouse plans and the direct seeding plans, a preferred buffer

amount of 15 to 20 percent is added to the minimum number of plants needed in the field.

- Variety selection is kept simple by changing no more than 10 to 15 percent of crop varieties each year. Limiting the quantity of new varieties trialed each year minimizes risk with an unknown commodity. Establishing a reliable baseline for crop performance is more important than novelty.
- The calculated plant date is the difference between desired harvest date and the days to maturity (DTM). In most cases, this calculated date is inaccurate. Traditionally, days are added in early spring and late fall to account for the cooler temperatures and slower growth. By June, seven to 10 days are subtracted off DTM to account for warmer temperatures and faster growth. The best method for calculating the ideal planting date is by referencing the actual DTM from the prior year's crops. The [Harvest Log](#) worksheet reflects the prior year's harvest data to determine which plantings did not mature as predicted, along with actual yield.

Crop Rotation

Crop rotation is a necessity for maintaining soil health and disrupting cycles of diseases and pest pressures. Several methods of crop rotation may be followed. These may include rotation by crop family, by nitrogen requirements, by cover crops and cash crops, by rooting depth, or by seasonality. One rule of thumb is to avoid planting the same botanical family in the same area within four years.

Table 2. Botanical family crop rotation reference.

Botanical Family	Example Crops in Family
Solanaceae (Solanaceous or Nightshade)	Potatoes, Tomatoes, Peppers, Eggplant
Fabaceae (Legume)	Peas, Beans, Clover, Vetch
Brassicaceae (Brassica)	Arugula, Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustards, Radish, Rutabaga, Turnips
Cucurbitaceae (Cucurbit)	Melon, Squash, Cucumber, Pumpkin
Asteraceae (Aster)	Lettuce, Artichoke, Radicchio, Sunflowers, Chamomile
Amaranthaceae (Amaranth)	Beets, Spinach, Chard
Amaryllidaceae (Allium)	Onions, Green Onions, Garlic, Leeks, Chives
Convolvulaceae (Morningglory)	Sweet Potato
Poaceae (Grass)	Sweet Corn, Popcorn, Rye, Oats, Wheat, Millet
Apiaceae (Umbel)	Carrots, Celery, Cilantro, Dill, Fennel, Parsley, Parsnips
Lamiaceae (Mint)	Mint, Basil, Rosemary, Sage, other herbs
Polygonaceae (Buckwheat)	Buckwheat, Rhubarb, Sorrel
Malvaceae (Mallow)	Okra
Other	Cover Crops (not cash crops)

Rotation, while necessary, does not always work systematically. A CSA program does not usually grow equivalent amounts of every crop family. In addition, being more land-limited means there is not a guaranteed fallow time for every field every year. While an ideal rotation may be a predetermined four-, six-, or eight-year rotation of vegetables, a static rotation like this cannot be implemented in the farming system. The complexity of a CSA growing system necessitates crop sequencing over crop rotation. The difference is that sequences are determined anew year to year, rather than several years in advance. In addition, smaller areas are considered in the crop sequences, which means that sometimes fields are divided into sections to sequence crops over a smaller footprint.

In addition to rotating botanical families away from the same land area, crops from the same families are not planted in adjacent areas, as adjacent plantings of the same family do not fully disrupt pest cycles. Set sequences are seldom ideal on every farm, but advantages and disadvantages of particular crop sequences do occur, which are noted after observation.⁸ Some of the land-based factors considered in sequence planning include: insect pressures, weed pressures, disease pressures (particularly if soilborne), organic matter content, and problem areas (such as those caused by compaction, poor drainage, slope, or exposure to wind).

The crop sequence plan is started by calculating the minimum return time. The minimum return time informs how many years the most limiting crop family can be rotated around the farm. The most limiting crop family is the one that occupies the most land space at a farming operation. To calculate minimum return time, add up the land area occupied by each family. The unit used will be the unit of rotation; generally, this would be crop beds or entire fields. Divide the total number of beds (or fields) planted at the farm by the number of beds occupied by the most land-intensive crop family. The result is the minimum return time, or the number of years the farm can rotate away from the crop family. This number guides all the following crop sequences, as rotation planning always begins by planning sequences with the most limiting family.

At UK-CSA, 25 percent of the acreage is planted in *Brassica* crops. Thus, the minimum return time is four years. If possible, a proactive plan is started to outline fallow years when fields are pulled out of production and planted in a cover crop for an entire growing cycle. Since UK-CSA is land-limited, double-cropping a field (spring and fall, summer and winter) is also done to take the double-cropped field out of production the year following for an entire cycle. Fallow fields are ideally planted with at least three cycles of successive cover crops for maximum soil building.

Table 3. Minimum return time for CSA crop rotation.

<i>Plant Family</i>	<i>Area</i>		<i>Percentage of Total Area</i>	<i>Max Rotation Period</i>
Brassica	61	beds	25.9%	4
Cucurbit	39.5	beds	16.8%	6
Nightshade	26	beds	11.0%	9
Grass	22	beds	9.3%	11
Legume	20	beds	8.5%	12
Umbel	18.5	beds	7.8%	13
Allium	16.5	beds	7.0%	14
Amaranth	13.25	beds	5.6%	18
Aster	10.5	beds	4.5%	22
Morninglory	6	beds	2.5%	39
Buckwheat	1	beds	0.4%	236
Mallow	1	beds	0.4%	236
Mint	0.5	beds	0.2%	472
<i>TOTAL</i>	<i>235.75</i>	<i>beds</i>	<i>100%</i>	

Mapping

Maintaining a historical record of field maps, as illustrated on the two [Historical Rotation](#) worksheets, is a helpful tool to inform crop sequencing decisions. By color coding the maps to correspond to botanical family, a glance at each field is a quick guide for the options to maximize botanical family rotations.

After assessing the overarching goals of crop sequences and looking at historical sequences by botanical family, the next step is grouping different plantings together in fields. Field groupings are decided first by botanical family, followed next by dates of planting, and finally by dates of harvest. The goal is to group crops most closely aligned with all three categories before solidifying each field plan. By grouping planting dates close together in a given field, field preparations can be done en masse without leaving too much soil bare and exposed. This also means that the number of cultivation passes to keep weeds under control in those empty beds will be minimized. By grouping harvest dates close together in a given field, fields can likewise be emptied en masse, allowing that entire field to be turned over to a cover crop, rather than having partial fields in cover crops.

Once the field assignments are made, individual maps like the [Example Field Map](#) are drafted for each field. These maps inform the entire team about what gets planted where, when, and how. Maps not only show the crop to be planted, but they include the corresponding settings for the equipment. Information on printed maps includes field and planting orientation, crop variety name, target planting date, number of rows per bed, in-row spacing, settings for the vacuum seeder (for direct seeded items), fertilizer requirements and accompanying machine settings for fertilizer output.

Calendars

The completed [Crop Plan](#) worksheet is used to draft calendars to keep the farm on track with target planting dates.

- A [Field Preparation Calendar](#) is used to give ample time to prepare the field for planting or seeding, as well as to give time for shallow cultivations to reduce weed pressure.
- Planting dates are used to draft a [Greenhouse Production Calendar](#) that includes crop variety names, seeding date, tray size, number of trays, and any special instructions.
- A [Planting Calendar](#) is drafted to include all crops that are vacuum seeded or transplanted in the ground. Anything scheduled for a given week will get seeded on the earliest day possible for that week, depending on the weather. The Planting Calendar includes crop variety names, seeding and planting dates, field location, rows per bed, and notes.

Table 4. Field preparation scheduling guidelines.

Activity	Time before 1st Planting in Field
Flail Mow	6-8 weeks
Primary Tillage, Bare Ground	4-6 weeks
Primary Tillage, Plasticulture	6 weeks
Secondary Tillage, Bare Ground	Immediately before stale seedbed cultivation begins
Secondary Tillage, Plasticulture	Immediately before installing plastic beds
Stale Seed Bed, Bare Ground	4 weeks (1st pass), Weekly after tillage and before planting (3-4 passes total)
Drip Irrigation Laying, Bare Ground	4 weeks, at time of 1st Stale Seed Bed pass
Plastic Laying	3 weeks
Plastic Cultivation	Weekly after plastic beds installed, until living mulch seeded
Basketweeding/Fingerweeding	Weekly after planting and seeding, depending on crop growth

CSA Crop Management

Greenhouse Production

A controlled environment like a greenhouse gives a jump start on the growing season. Some crops are well suited to transplanting while others are best to be direct seeded, and some are equally suited to either transplanting or direct seeding. On occasion, beets, chard, spinach, and radishes are transplanted, though usually direct seeding is preferred. In addition, cucumbers are usually direct seeded, because they are

Tip: Seeding events are grouped together on the same day as much as possible, so that seeding or planting only occurs one day a week. It is better to seed some crops early to maximize efficiency when considering the time to set up equipment. The primary crops that need to be seeded close to their exact calculated date for days to maturity include sweet corn and green beans.

fast growing and tend to break when transplanted. If cucumbers are given a minimal amount of time in the greenhouse, they can also be transplanted.

Transplanting maximizes crop efficiency by starting with a vigorous plant grown in optimal conditions prior to being planted. The risk of transplanting crops is loss through shock as they adjust to outdoor growing conditions. This shock is mitigated by a process known as “hardening off.”

Managing the greenhouse production includes seeding crops in a timely fashion, monitoring germination, fertilizing, hardening off appropriately, scouting for any pest or disease issues, and potting up when appropriate. Some crops benefit from developing more extensive root balls by moving them from a small tray size to a large tray size. This practice can be labor-intensive, but the benefits to plant health before the plant goes in the ground make the time investment worthwhile. Crops that will be potted up to a larger tray include herbs, flowers, celery, eggplant, leeks, peppers, and tomatoes. Proper greenhouse management is critical for optimum plant health and vigor; standard operating procedures (SOPs) are useful for training workers.

Table 5. Recommended crop planting methods.

<i>Crop</i>	<i>Direct Seed</i>	<i>Transplant</i>	<i>Potting Up</i>
Arugula	✓		
Basil		✓	
Beets	✓	✓	
Bok Choy		✓	
Broccoli		✓	
Brussels Sprouts		✓	
Cabbage		✓	
Cantaloupe		✓	
Carrots	✓		
Cauliflower		✓	
Celery		✓	✓
Cilantro	✓		
Cucumber	✓	✓	
Dill	✓		
Eggplant		✓	✓
Fennel		✓	
Garlic		✓	
Ginger		✓	
Green Beans	✓		
Green Onion		✓	
Kale/Collards	✓	✓	
Kohlrabi		✓	
Leeks		✓	✓
Lettuce Head		✓	
Lettuce Mix	✓		
Mustard Green	✓		
Napa Cabbage		✓	
Okra		✓	
Onions		✓	
Pepper		✓	✓
Popcorn	✓		
Potato		✓	
Pumpkin		✓	
Radish	✓		
Rutabaga	✓		
Spinach	✓	✓	
Summer Squash		✓	
Sweet Corn	✓		
Sweet Potato		✓	
Swiss Chard	✓	✓	
Tomato		✓	✓
Turmeric		✓	
Turnips	✓		
Watermelon		✓	
Winter Squash		✓	

The quality of the media and length of time a seedling is in a tray will determine frequency of additional fertilizing. Winstrip trays are used at UK-CSA; these trays have a unique pattern on their surfaces that situates each cell next to an air column. Slits in the sides of the cells allow the roots to be “air pruned” and prevent plants from becoming rootbound. These trays are also made of thick plastic that can be washed, sanitized, and reused.



Figure 2. Copies of the greenhouse SOPs and the greenhouse calendar are kept in the greenhouse facility itself. The sheets are placed in a waterproof ticket holder that can be hung on the wall for quick reference.



Figure 3. Onions seeded on the same day, with ProMix potting media used on left and Vermont Compost potting media on right. Neither seeding received any fertigation. Stunting resulted when crops seeded with ProMix were not fertigated on a regular schedule.

There are four standard sizes of trays used, and the numbers correspond to the quantity of cells in each tray. Larger numbers have smaller cells per tray, while smaller numbers have larger cells per tray.



Figure 4. Winstrip tray.

The size of tray used during the seeding depends on the crop, the number of weeks it stays in the greenhouse tray, and the planting method. Crops that take a long time to develop a strong root structure, like herbs, are started in smaller trays. Crops that grow rapidly are sown in a large tray size at the outset. Any crop that will be transplanted into bare ground cannot be larger than one square inch for use with the equipment.

Seeds are stored in airtight containers under refrigeration for optimal performance. Seeds are sorted by crop, placed in labeled and closed poly bags, and grouped into totes for easy organization. Before organizing seeds for storage, notes are made of germination percentages on the package label. Whenever germination percentages are below 90 percent, a larger buffer amount will be given. While crop plans do include a 15 to 20 percent seed buffer, this information can indicate when to adjust seeding rates for different varieties.

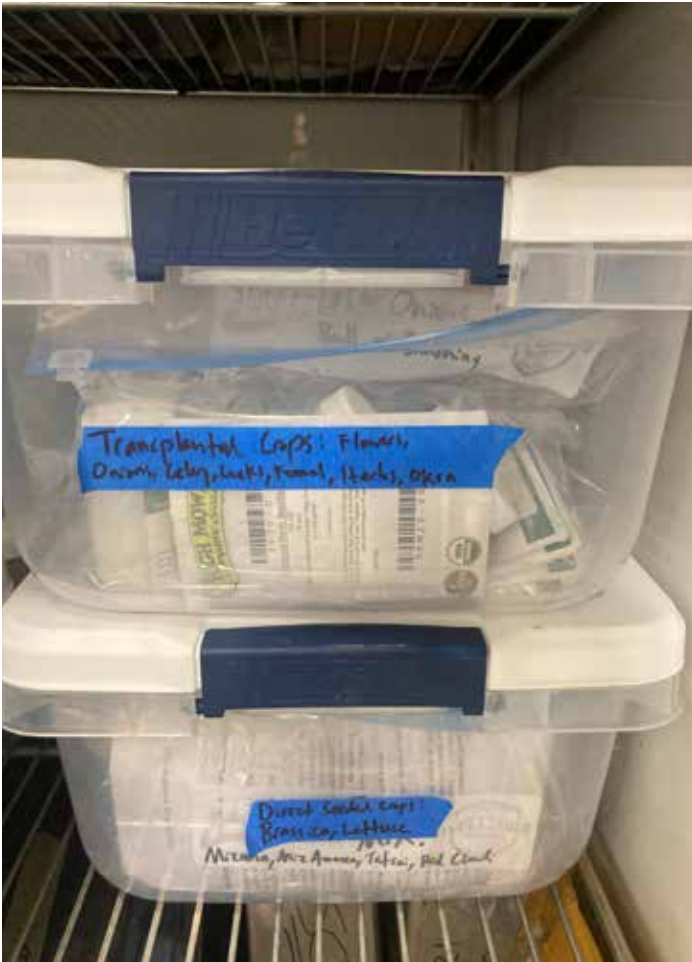


Figure 5. Labels facing out on the seed storage totes help workers find the correct seeds quickly.

Table 6. Greenhouse Winstrip tray selection guide.

Winstrip Tray	Cell Size	Crops
162	0.9 in ²	Herbs; Germinating Eggplant, Flowers, Peppers, Tomatoes, Onions
128	1 in ²	Basil, Brassicas, Fennel, Green Onions, Leeks, Lettuce
72	1.3 in ²	Melons, Okra, Summer Squash, Sunflowers, Winter Squash; Potting-up Leeks, Flowers
50	1.6 in ²	Potting-up Eggplant, Peppers, Tomatoes

Many seeds can last several years under proper refrigeration. Based on experience, most seeds are still viable two to three years after their purchase date. The “germ date” listed on the front of a seed envelope indicates when they were last tested and serves as a guide in determining how long to keep seeds past that date. Most herbs are replaced annually, as germination percentages decrease significantly for older seed. In addition, it is best practice to use up any pelleted seed in the year it is purchased. Some seeds also undergo hot water treatment. While it is advisable to use hot water-treated seed in the same season it is treated, no significant germination decreases occurred after holding hot water-treated seed for one whole year.

Seeds can be sown by hand or using a greenhouse vacuum seeder. Refer to the sections on [Greenhouse Seeding](#), [Greenhouse Vacuum Seeding](#), [Greenhouse Potting Up](#), [Greenhouse Hardening Off](#), and [Greenhouse Management](#) in the UK-CSA SOP Manual for more information.

Soil and Field Preparations

The UK-CSA is situated on a Maury silt loam soil. A starting point for understanding more about a farm's soil is the USDA Web Soil Survey (WSS).⁹ The WSS identifies soil types and characteristics in given geographic areas.

In addition to identifying soil type and tracking field crop rotation history, notes are made on field characteristics. Some fields are not suited for all types of crops. Factors considered in field analyses include slope, drainage, compaction, aspect, shade, air drainage, visibility, organic matter, tilth, nutrient imbalances, erosion potential, annual weed pressures, perennial weed pressures, disease problems, animal pressures, proximity to landmarks, neighbors, or other farm features like windbreaks or trees. These characteristics indicate limitations as well as opportunities for crop choices in the farm's fields. Here are some examples of how UK-CSA has responded to field characteristics at the OFU:

- One field suffered from an outbreak of Canadian thistle. This field was taken out of production, tilled aggressively, and then planted in heavy rotations of cover crops to smother the thistle. This field is not in production.
- Fields with rhizomatous weed pressure, such as perennial Johnson grass, are ill-suited for direct-seeded crops, especially carrots. Since Johnson grass cannot be killed with flame weeding, the long germination period for carrots will allow the Johnson grass to get a head start.
- One field borders a fence line adjacent to a public park. The proximity of this fence line to the public area made it difficult to find a window of time to reliably spray that field when no person would be affected. This field is now used for crops that do not require frequent spraying.
- One field has a slope of more than 2 percent on the northern third. Due to this slope, plastic mulch-covered raised beds are usually used in this field. Driving bare-ground cultivation implements in this field is challenging, particularly for inexperienced tractor drivers; implements slide across the beds at an angle when driving along the slope and cut into the neighboring beds. With plastic mulch beds, there is wider spacing between them, and erosion potential is minimized by planting a living mulch between the plastic.
- A nutrient deficiency occurred in a field that had used a straw mulch the prior season. This high-carbon mulch did not have enough time to break down when it was time to plant spring crops. This straw tied up some of the fertility, causing severe stunting and yellowing on plants planted in areas where this straw was still present. Fields that use a straw mulch the prior year are given a longer time before the next planting, and if possible, successive annual plantings in these fields are avoided altogether.

Each fall, soil samples from each of the fields or management units are taken and submitted to a lab for analysis.¹⁰ The soil test results guide management decisions for additional fertility required, if any, for the crops that are being grown that upcoming season.

Compost applications are an amendment of organic matter that contributes to a soil's tilth. The tilth of a soil refers to the physical characteristics that contribute to the soil's ability to support the planting and growing of crops. Organic matter additions to the soil will benefit the soil's water- and nutrient-holding capacity, friability, porosity, and particle aggregation, as well as alleviating compaction.

The compost application is completed in fall to guarantee a minimum of 120 days for the pre-harvest interval, the time between manure application and the harvest of crops that come in contact with soil. This longer time frame is necessitated by NOP requirements since the amendment used at UK-CSA is not certified compost.¹¹



Figure 6. Soil aggregates are a sign of good tilth.

The desired compost (or manure) application rate is 10 tons per acre, which is applied using an H&S manure spreader Model 125. On a small scale, a drill-powered tool called a tilter incorporates compost into individual beds.

Field preparation involves both primary and secondary tillage operations. The goal of tillage is to prepare a field for the crop to be sown there while minimizing disturbance to the weed seed bank. Soil disturbance will bring weed seeds to the soil surface; therefore, all tillage operations are kept as shallow as possible and tillage passes are kept to the fewest possible to reduce the amount of disturbance.

Every four to five years, fields are prepared by subsoiling in the fall to break up plow pan that can develop over time.

When entering a new field in the following year, the first step is to mow any overwintered cover crops. If the cover crop winter-killed, mowing may be unnecessary unless there is

substantial stubble. Thick residues can be broken up by using a chisel plow or a disc harrow after mowing, if needed.

The standard primary tillage pass is accomplished with a spader. The spader works at a depth of four to eight inches, digging into the soil without inverting it. Tines on the back end of the spader finely cultivate the top one to two inches to create a proper planting surface. If a field cannot be put into beds right away, a field cultivator can be used to destroy weeds that pop up until the beds are formed.

Occasionally, planting starts immediately after spading. However, if the soil contains larger clods, a secondary tillage operation with a rototiller may be necessary. While rototilling is more destructive to soil, damage is minimized by proper depth control. Only the top inch of the soil profile is tilled for minimal soil disturbance.



Figure 7. A bucket loader fills the manure spreader before it drives over the fields to spread the composted manure.



Figure 8. Spreading partially composted manure in fields with H&S PTO-driven manure spreader.



Figure 9. The Tilther, sold by Johnny's Selected Seeds, is run on a battery-powered drill. By pulling a rope connected to the drill, the tines are activated and rotate to incorporate compost, soil amendments, or small amounts of residue.



Figure 10. Subsoiler.



Figure 11. Flail mower.



Figure 12. Chisel plow.



Figure 13. Disc harrows.



Figure 14. Imants spader, 27 series.



Figure 16. Field cultivator.



Figure 15. Imants spader, 38 series.



Figure 17. Maschio rototiller.

Bed Installation

Most of the field production at UK-CSA is done in either a bare-ground system or a plastic mulch-covered raised-bed system. For the bare-ground system, a stale seedbed cultivator is used to shape the beds. This implement is also versatile in reducing the weed pressure. By going over the bed with three to four passes before planting, with each pass spaced seven to ten days apart, the weed pressure on that bed will be reduced by 93 to 98 percent.¹²

A 50-foot-wide field can fit 10 bare-ground beds. After the first stale seedbed passes, the beds are set in the field. The initial stale seedbed pass forms a bed top, which also serves as a

guide for lining up the subsurface irrigation drip layer. Immediately after installing the subsurface drip lines, the beds are passed over with the stale seedbed implement a second time to smooth the surface. This implement runs on top of the drip lines without snagging or disturbing them, but its weekly use continues to reduce weed pressure prior to planting.

In the plastic system, up to eight plastic beds can fit in a single 50-foot field. Bed centers are marked with flags at even spacings for easy tractor alignment, if needed. Fewer plastic beds per field are preferred for crops like tomatoes that benefit from increased air circulation to minimize disease pressure.



Figure 18. Custom stale seedbed cultivator.



Figure 19. Ten bare-ground beds ready for planting.



Figure 20. Custom Andros subsurface drip layer.

Some crops are best suited for different types of plastic mulch. Three types used include: black, white, and aluminized. Black is best suited for crops that are heat loving. White is preferred for crops that benefit from more reflectivity or for slightly cooler temperatures in midsummer. Aluminized plastic is useful for repelling insect pests like thrips and flea beetles. Netting the crops controls insect pests when susceptible crops are not grown on reflective mulch.

Tip: Be sure that workers wear sunglasses when installing aluminized plastic mulch. On a sunny day, it is highly reflective.



Figure 21. Keeping plastic beds straight at installation with visual guides.

Figure 22. Aluminized plastic.

Table 7. Plastic mulch selection by crop.

Plastic Mulch Selection	
Black	Early Tomatoes, Eggplant, Flowers, Garlic, Herbs, Peppers, Summer Squash, Sweet Potatoes, Watermelon
White	Cantaloupe, Late Tomatoes, Winter Squash, Garlic
Aluminized	Cantaloupe, Eggplant, Onions, Summer Squash, Winter Squash

For smaller, intensively planted areas like high tunnels, tillage is managed with a walk-behind tractor (BCS) and an assortment of implements. The primary bed preparation implements used with the BCS walk-behind tractor include a flail mower, rotary plow, tiller, and power harrow. Quick bed turnovers are managed by using a broadfork or digging fork to break compaction, and minimize tillage passes.

Table 8. Plastic mulch installation spacing by crop.

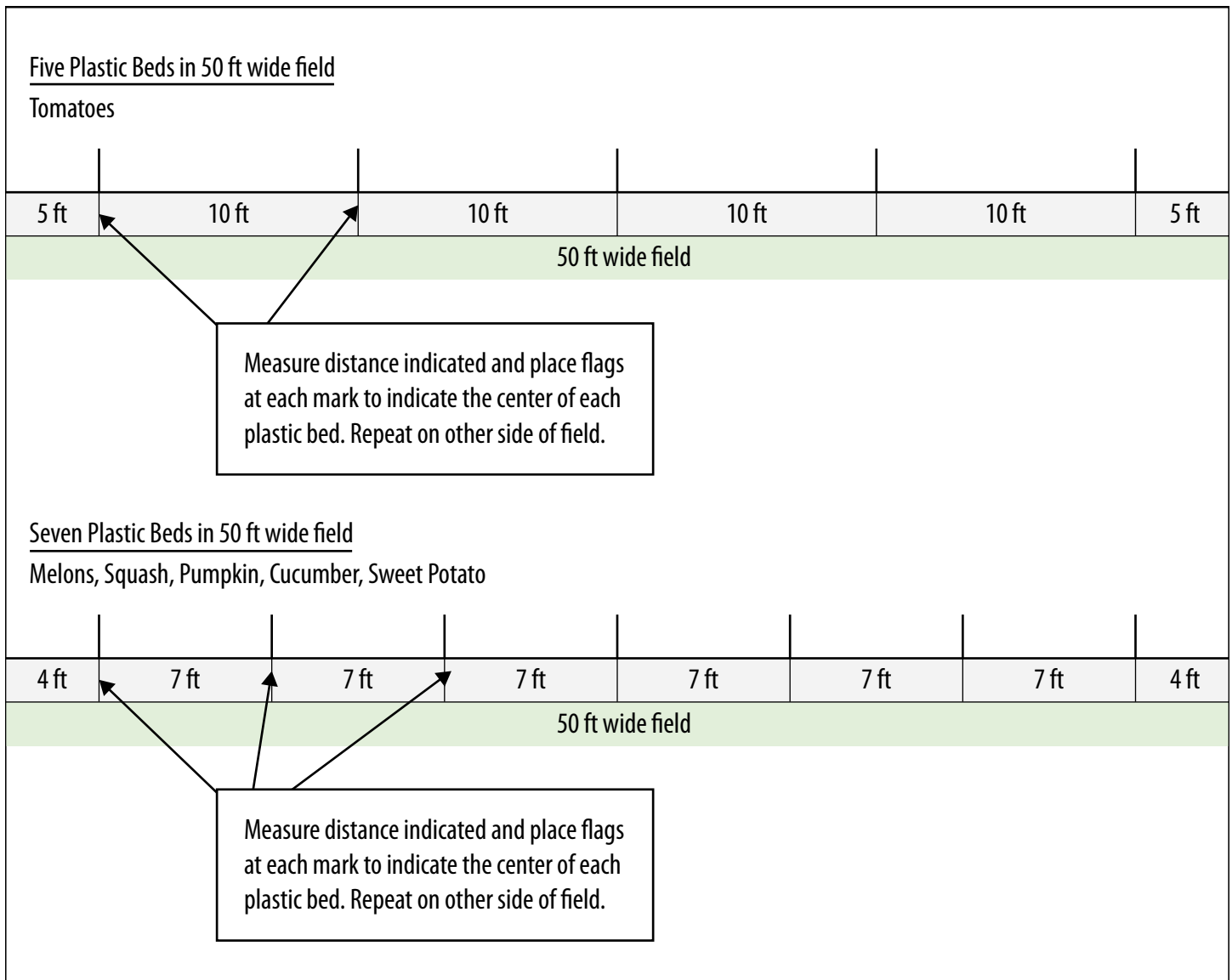




Figure 23. A broadfork is used to alleviate compaction between succession plantings on smaller beds.



Figure 25. BCS flail mower.



Figure 24. BCS rotary plow.



Figure 26. BCS power harrow.

Planting

UK-CSA utilizes three distinct planting systems. The standard is the bare-ground system, with two rows of crops per bed measured at 18 inches apart. These beds are either planted by direct seeding with a MaterMacc Precision Vacuum Seeder or MaterMacc VegiMacc Vacuum Seeder, or by transplanting with the Mechanical Transplanter 5000.

The second planting system is plasticulture. The use of black, white, or aluminized plastic mulch conserves water and reduces weed pressure. Plants are hand transplanted into the plastic beds, often with the aid of a Rain-Flo Model 1600 water wheel transplanter.

The biointensive planting system is the third planting system, which utilizes multi-row beds, shorter in length, and packs more crops on a smaller land footprint. Crops are hand planted using trowels or soil knives, or they are seeded using a Jang JP-6 push seeder. This system is similarly applied within controlled growing environments, including both high tunnels and a solar greenhouse. Beds can be marked for planting using a seedbed roller with dibblers or a bed preparation rake with extended tines for row markers. These tools facilitate seeding and transplanting with even spacing in-row and/or between rows.



Figure 27. The MaterMacc VegiMacc vacuum seeder.



Figure 28. Mechanical Transplanter 5000.



Figure 29. Rotating carousel holds individual plants.



Figure 30. Plant plugs drop down chutes and get a spurt of water before being buried.



Figure 31. The Rain-Flo Model 1600 water wheel can hold one to three wheels for one- to three-row production systems. The wheel punches a hole into the plastic and creates a dibble, while a stream of water is sent into the hole.



Figure 32. Workers wear nitrile gloves to push plants in the plastic bed by hand.



Figure 33. The 36-inch seedbed roller packs bed tops while dibbling holes. Dibble spacing is customizable.



Figure 34. Bed preparation rake.



Figure 35. A six-hopper Jang push seeder can seed between one and six rows per bed at a time.

Cover Crops

A cover crop is any cover that is intentionally planted into the farming system for benefits other than that of a cash crop. Cover crops serve several valuable roles in the farming system:

- Covering soil to prevent wind and rain erosion, particularly in the off-season
- Adding organic matter back to the soil for benefits of water-holding capacity, porosity, soil aggregation, and feeding of microbial life
- Alleviating soil compaction
- Providing a nitrogen boost to the soil through leguminous crop nitrogen fixation
- Reducing leaching of nitrogen by scavenging for nitrogen in the soil
- Inhibiting weed germination via allelopathy
- Attracting pollinators and providing refuge for beneficial insects
- Contributing to the farm's overall crop rotation plan
- Outcompeting and suppressing weeds

Cover crops can be categorized as leguminous or nonleguminous. Leguminous cover crops grown include clovers, vetches, peas, and sunn hemp, all of which will add nitrogen to the system when terminated at the proper time.

Nonleguminous cover crops include millet, barley, oats, wheat, annual ryegrass, sorghum Sudan grass (sudex), teff, and buckwheat. Many of the nonleguminous cover crops are seeded where an increase in organic matter is prioritized



Figure 37. Oats and peas drilled in a fall field.



Figure 38. A worker fills the no-till grain drill with cover crop seed.



Figure 36. Nodulation on roots of a legume cover crop is from nitrogen fixation.

over nitrogen benefit. In Kentucky's climate, some of the cover crops will overwinter while others will winter-kill, which means they will die over the course of the winter season. If the field with a cover crop is intended for an early cash crop the following year, a winter-killed cover crop will be desirable to aid in faster turnover and breakdown of the organic matter.

Examples of late summer or early fall seeded cover crops for winter-killing include oats and Austrian winter peas. They should be seeded between August and October 10.

Examples of mid to late fall-seeded cover crops for overwintering include cereal rye and crimson clover. They should be seeded between October 1 and November 10.

Table 9. Cover crop selection and seeding rates.¹³

<i>Crop</i>	<i>Type</i>	<i>Benefits</i>	<i>Singular Rate</i>	<i>Mixture Rate</i>
Austrian Winter Pea	Legume	Will winterkill in Zone 6	90 lbs/A	48 lbs/A
Cowpea	Legume	Adds nitrogen, good option for summer niche	100 lbs/A	60 lbs/A
Crimson Clover	Legume	Will overwinter in Zone 6, nice flowers in spring	25 lbs/A	10 lbs/A
Hairy Vetch	Legume	Adds nitrogen, attracts beneficials	25 lbs/A	20 lbs/A
Medium Red Clover	Legume	Will overwinter in Zone 6, versatile mixed in living mulches	25 lbs/A	10 lbs/A
Sunn Hemp	Legume	Adds nitrogen, fast growing, heavy biomass	55 lbs/A	30 lbs/A
Buckwheat	Non-legume	Fast growing, early flowering for pollinators	48 lbs/A	30 lbs/A
Cereal Rye	Non-legume	Heavy biomass, will overwinter in Zone 6	70 lbs/A	20 lbs/A
Japanese or German Millet	Non-legume	Versatile and economical early summer living mulch	70 lbs/A	20 lbs/A
Oats	Non-legume	Will winterkill in Zone 6	80 lbs/A	30 lbs/A
Peredovic Sunflower	Non-legume	Beautiful flowers attract pollinators	20 lbs/A	
Sorghum Sudan Grass	Non-legume	Heavy biomass	35 lbs/A	15 lbs/A
Teff	Non-legume	Can withstand multiple mowings, great for living mulch	15 lbs/A	15 lbs/A
Winter Barley	Non-legume	Early maturing, can use for succession	50 lbs/A	36 lbs/A

Examples of late spring- or summer-planted cover crops, suited for hot growing conditions only, include sorghum Sudan grass, sunn hemp, buckwheat, and teff. These crops are best seeded between May 1 and September 1.

Frequently, multiple species of cover crops are mixed in one planting to maximize the breadth of benefits, employing both leguminous and nonleguminous species. Examples of mixes include cowpea, buckwheat, and German millet for summer; oats, Austrian winter peas, and clover for late summer/early fall; and cereal rye, vetch, barley, and clover for late fall.

Cover crops are seeded using a Tye Pasture Pleaser no-till grain drill. Some succession cover crops can be sown direct into a previous year's residue without mowing in advance. Occasionally, disking will be required after mowing to break down residues for better cover crop seed-to-soil contact.

Living mulches are a cover crop integrated into a field setting during the active growth period of the cash crop. Most commonly, these crops are grown in between rows of plastic mulch beds. However, this is not the only application of living mulches. They can also be undersown along with a cash crop with reduced canopy coverage, like kale, in a bare-ground system. Mulches are effective at weed control for long-season crop fields and are easily managed by periodic mowing. Effective living mulches include:

- Teff sown between tomato and pepper beds
- Clover and cereal rye sown between fall garlic beds and other fields installed with plastic the previous fall
- Millet and clover for midsummer living mulches
- Crimson or red clover undersown for late fall brassicas



Figure 39. A BCS flail mower is used every one to two weeks to mow.



Figure 40. Teff in the aisles of the tomato field.



Figures 41 and 42. Drop spreaders suitable for undersowing and broadcasting living mulch seed between beds of plastic.

Living mulches are not planted in all production fields, primarily because of the timing for establishment and crop growth patterns. Quick-growing crops like early summer squash do not provide long enough windows of time for establishing the living mulch in early spring before the field is being mowed down. Vining crops like winter squash and melons will grow off the beds, making mowing living mulches impossible. Cultivation is generally preferred to living mulches for these crops, but the use of living mulches that are terminated early or straw mulch may be feasible. Other crops, like sweet potatoes, vine out so quickly that the plants themselves provide shade and outcompete weeds.

Living mulches are spread by use of a drop spreader pushed through the aisles or hand sown from a five-gallon bucket. To provide proper contact between the seed and soil, the soil is disturbed prior to spreading and/or lightly cultivated with a plastic cultivator, mini field cultivator, or scuffle hoe after sowing.

Cover crops are also used strategically for the benefit of the cash crops. Flowering cover crops act as refuge for beneficial insects and attract pollinators. In addition, buffer strips of buckwheat are routinely planted for these purposes, as well as for natural shading on summer lettuce. Planting buckwheat two to three weeks prior to lettuce on the east side blocks morning sun and keeps plants cool for a longer time, thereby helping to delay bolting.



Figure 44. Grasses and buckwheat provide shade cover to summer lettuce.



Figure 43. Buckwheat on field edges attracts pollinators.



Figure 45. Early establishment of a living mulch makes you-pick opportunities for CSA members more enjoyable and less muddy.

Fertility

Proper fertility is vital for a successful CSA and for growing high-quality crops. Vegetables that are nutrient deficient are stressed, may grow improperly or inconsistently, and are more susceptible to pest and disease pressures.

There are numerous sources of fertility, including cover crops, compost, soil organic matter (SOM), and granular or liquid fertilizer inputs. Soil tests will provide valuable information about the pools of fertility already in the soil.

Most fertilizer inputs contain the primary nutrients of nitrogen, phosphorus, and potassium, or N-P-K. In organic systems, fertility sources must be OMRI approved, which means all inputs that are used in agriculture have been independently reviewed by the Organic Materials Review Institute as meeting National Organic Program (NOP) standards. These inputs are biologically derived, frequently from either animal or plant sources; common examples include chicken litter, pork meal, kelp, or seaweed. At UK-CSA, fertilizer used is Nature Safe 10-0-8 Nitrogen and Potassium Fertilizer with Ocean Organics Kelp Extract. A phosphorus-free fertilizer is selected due to consistently adequate phosphorus levels in the soils. Nature Safe fertilizer reaches 60 to 65 percent mineralization after eight weeks.¹⁴ Crops that are in production past eight weeks (56 days) are eligible to receive fertigation, but fertigation is only initiated for crops that mature in over 70 days. Fertigation is not made when crops will mature within two weeks of the 65 percent fertilizer mineralization date. Fertigation is a process of injecting a liquid fertilizer in the irrigation lines. Crops that benefit from fertigation at UK-CSA include head cabbages, tomatoes, peppers, eggplant, cauliflower, celery, and cantaloupe. See the [Field Fertigation](#) section in the UK-CSA SOP Manual for more information.



Figure 46. Example of a fertilizer hopper on the back of an implement.



Figure 47. Fertilizer drop rate is adjusted by rotating the knob below the hopper.



Figure 48. Control boxes are adjustable for fertilizer drop rate.

Implements that will side-dress or band fertilizer include the Mechanical Transplanter planter, MaterMacc vacuum seeders, Lilliston rolling cultivators, and the Rain-Flo plastic layer. The fertilizer application rate on each of these implements can be adjusted manually by changing the opening size on the fertilizer hoppers, by switching gears on ground-driven implements, or by making electronic adjustments with Servi-Speed control boxes. To determine fertilizer output, weigh how much fertilizer is dropped in 15-second intervals at each setting. With a constant speed on the tractor, output over a given distance can be determined and converted to pounds of nitrogen applied per acre. See Example 1 on next page.

To determine the desired rate of fertilizer to drop, the nitrogen credits from SOM, cover crops, and three-year historical fertilizer rates need to be considered in addition to the specific crop needs. See the [Fertility Planner](#) Workbook to determine target fertilizer rates by field and crop.

Example 1: Calculating Fertilizer Output with the Servi-Speed Control Box

Set control box to "5". In 15 seconds, the control box drops 1.2 pounds of fertilizer. The fertilizer is a 10-0-8 product, providing 0.12 pounds of nitrogen (N) in that time interval.

$$1.2 \text{ pounds} / 10 = 0.12 \text{ pounds N output in 15 seconds}$$

The field is 300 feet long, or .057 miles long.

$$300 \text{ feet} / 5,280 \text{ feet per mile} = .057 \text{ miles}$$

At medium and in third gear, the tractor used will travel 2.14 miles per hour, or .036 miles per minute.

$$2.14 \text{ miles} / 60 \text{ minutes per hour} = .036 \text{ miles per minute}$$

The 300-foot bed will be traversed in 1.58 minutes.

$$.057 \text{ miles} / .036 \text{ miles per minute} = 1.58 \text{ minutes}$$

In this time, 0.76 pounds of nitrogen will be dropped in the bed.

$$1.58 \text{ minutes} \times 60 \text{ seconds/minute} = 94.8 \text{ seconds}$$

$$94.8 \text{ seconds} / 15 \text{ seconds intervals} = 6.32 \text{ intervals}$$

$$6.32 \text{ intervals} \times 0.12 \text{ pounds nitrogen output per interval} = 0.76 \text{ pounds N per bed.}$$

Each bed is 300 feet long by three feet wide, or 900 square feet. Based on 43,560 square feet per acre, 48.4 beds of crops can fit on one acre.

$$43,560 \text{ square feet} / 900 \text{ square feet per bed} = 48.4 \text{ beds per acre}$$

This gives a drop rate of 36.7 pounds N per acre.

$$0.76 \text{ pounds N per bed} \times 48.4 \text{ beds per acre} = 36.7 \text{ pounds N per acre}$$

Irrigation

See the [Irrigation Management](#) section of the UK-CSA SOP Manual for complete details on determining irrigation event timing and duration.

Plant available water is another critical component to plant health. While Kentucky averages 40 to 53 inches of rainfall annually, summer precipitation only averages around 12 inches, so droughts and crop stress can occur.¹⁵ Irrigation also has a direct correlation to consistent and predictable crop germination and yields. Crops are irrigated by overhead sprinklers or drip tape irrigation lines. Drip tape is a flat tube that trickles out water at even emitter spacings when filled. The water emerges from the top of the tape and spills over the sides. This irrigation method results in less evaporation and can result in 85 to 99 percent water uptake efficiency.¹⁶

UK-CSA irrigates from municipal sources only, and water usage monitoring is key. Drip irrigation is used across the farm, connected to Sun-Flow blue PVC water discharge hoses, or “layflat,” by a custom-built manifold. The standard type of drip tape used is eight-mil Toro Aqua Traxx, with a six-inch emitter spacing. Two lines of drip tape are buried in each bare-ground bed, while only one line of drip tape is installed below the plastic mulch beds.

In intensive systems, drip lines are run on top of beds, but in the one-third-acre field plots, drip tape is buried using an Andros custom subsurface drip layer. The Andros subsurface drip layer can be adjusted for different depths. The goal is to keep the drip lines at the root zone for maximum efficiency. Burying the tape at a depth of roughly three inches, but no more than four inches, will be close enough to the root zone yet still low enough to cultivate on top of the soil with impunity to the drip lines. Occasionally, drip lines will be manually pulled out on top of beds or oscillating sprinkler heads will be temporarily installed to aid in quick germination. Drip lines that run subsurface can take a long time to percolate upwards when necessary to germinate seeds. Therefore, having a method of wetting the soil surface when a rainfall event is not in the forecast is imperative for some crops, like carrots. The alternative is to coordinate seedings with the weather forecast, e.g., to direct seed carrots right before an expected rainfall, and plant earlier when able.

At the end of a season, drip lines must be removed from the fields. A custom drip lifter will dig underneath the lines and loosen them. The lines can then be rolled up mechanically if loose, or they will have to be manually pulled up if they were not fully loosened by the lifter.



Figure 49. A worker checks the depth of the drip lines being installed with the Andros drip layer.



Figure 50. Sprinklers set up to reduce soil crusting and aid germination.



Figure 51. A drip lifter leaves the lines laying on top of the bed for easy pickup.

Weed Management

The plastic beds are cultivated on their shoulders using an IH Farmall 140 with a custom power-steering system; belly-mounted, straight-tooth cultivators; and small hilling discs for plastic bed-shoulder cultivation. Rear-mounted Danish S-tines cultivate the wheel tracks. This cultivator is referred to as the “plastic cultivator.” For some crops, a living mulch is sown between the plastic beds for weed control. The living mulch is seeded after the beds are planted to minimize seed disturbance when using the water wheel setter and incorporated shallowly with one pass of the plastic cultivator.



Figure 52. Custom plastic cultivator.

An IH Farmall 140 with a custom power-steering system, belly-mounted Buddingh basket weeders, and rear-mounted spyder cultivators on Danish S-tines is used to shallowly cultivate bare-ground crops when they are very small. This implement is referred to simply as the “basket weeder” and is best used right after germination and until plants are either wider than two inches or taller than four inches. Crops that routinely get basket weeded include beets, carrots, spinach, lettuce mix, newly transplanted brassicas, green onions, cilantro, and dill. In addition, the basket weeder can be driven over freshly harvested, leafy green beds to disrupt the culled leaves and weed next to the plant stubble for a cleaner subsequent harvest.



Figure 53. Buddingh basket weeder.

A Kress Argus finger weeder is the second step in the cultivation process for the bare-ground system. Flexible “fingers” on the implement spin and allow for in-row cultivation. This capability allows for the most extensive cultivation and reduces the need for hand cultivation substantially. The fingers can be spaced closer together for more intensive in-row weeding or moved apart when plants are smaller and need to be handled more delicately. A smaller-scale finger weeder tool made by Terrateck can be pushed in high tunnels for similar cultivation.



Figure 54. Kress Argus finger weeder.



Figure 55. Terrateck double-wheel hoe with finger-weeding attachments.

The Lely Weeder, also called the “tine weeder,” is a blind cultivation method; the operator does not see where the crops are in relation to the cultivators. The tines themselves ride over top of the crop. The tine weeder is useful for cultivating entire fields (e.g., between rows of drilled cover crop seed after the cover crop is established, or on potatoes, which can withstand the disturbance).

Smaller-scale tools include the Farmers Friend Pyroweeder, a 30-inch-wide, flame-weeding push tool with five burners. The flame weeder is used mostly for carrots, which require a long germination period. Flame weeding will not kill grasses, therefore successful implementation requires a field-specific knowledge of the weed species that present a challenge.

The tine weeding rake, part of the Eliot Coleman Signature Series, is a smaller-scale version of the tine weeder implement, at only 21 inches wide. This is most effective on the thread stage of plant growth before true leaf development, when weed seedlings are still small. This is best used on crops that have had a little time to adjust to their surroundings and won't be disturbed by having the rake pulled over top of them.



Figure 57. Flame weeding carrots with Farmers Friend Pyroweeder.



Figure 56. Lely Tine Weeder.



Figure 58. Tine rakes are used for thread-stage weeds.



Figure 59. Glaser wheel hoes cultivate wheel tracks, bed shoulders, and areas between plant rows.



Figure 60. The hot bed weeder is a versatile precision hand-weeding tool.

Chop hoes are useful when getting rid of clumps of grass or weeds that have more enmeshed root systems. They can be used to slice the crops off at the surface. Hoes like the collar hoe, stirrup (or “scuffle”) hoe, torsion hoe, wire hoe, and Glaser wheel hoe are good for getting in tight spaces while remaining upright. These all disturb the top quarter inch of soil for minimal soil disruption and do not require a lot of force to operate.

Hand tools like the hot bed weeder, wire weeder, and Leonard Cape Cod weeder are best used for precision weeding and thinning on ground level and in row for small, seeded crops like carrots, cilantro, dill, and beets.

Cultivation on the farm is a regular occurrence. Weeding before a big rain is a priority, as a rainfall event can significantly add growth to small weeds. One rainfall event is enough to make weeds uncultivable by the implements, which requires they be removed by chop hoes or even string trimmers. String trimmers, while not mentioned in this suite of cultivation tools, are used as a last resort when weeds have escaped cultivation to keep them from setting more seed in the field.

Integrated Pest Management

Pest and disease management is achieved by a multiplicity of practices. Cultural controls, physical controls, and chemical controls are all part of an integrated pest management (IPM) plan.

Cultural controls for reducing both insect and disease pressures include proper crop sanitation by removing diseased/affected plants; removing or mowing and tilling under old crop debris; planting flowering buffer zones that may act as trap crops or beneficial insect refuge; choosing disease resistant varieties of seeds; crop rotation; and introducing parasitic or predator insects to target specific crop insect pests.

A perennial herb and flower area serves as an overwintering shelter for beneficial insects as well as attracting more beneficials and pollinators when flowering. Buckwheat is a quick-flowering cover crop in summer, and whenever a field has space, a row of buckwheat is planted next to the crops to flower and attract beneficial insects throughout the growing season. A field edge buffer of sunflowers works well planted next to corn, due to similar growth patterns. They attract many pollinators and beneficial insects, and the sunflowers themselves are harvested and handed out in the CSA.



Figure 61. Sunflower field edge next to corn.

Beneficial insects like parasitic wasps, green lacewings, and lady beetles help to keep pest populations in check. Some pests that are controlled with parasitic and predator insects include aphids, moth eggs on cole crops, thrips, whiteflies, and leafhoppers. When released in a field or open area, there is no guarantee the insects will stay around. However, when released under insect netting, there is a better chance of control. Any beneficial insect release is made early, before the pests are an issue. For example, cantaloupe consistently suffers from aphid outbreaks on young plants. This pest is anticipated now on an annual basis. The strategy is to introduce green lacewing eggs every week for three weeks after planting under an insect net to keep aphid populations in check. This has been successful and reduced the need for an early chemical spray.

Cultural controls for diseases include bleaching tools during harvest and pruning, preventing irrigation water from splashing on leaves, or placing plants under cover in a high tunnel or haygrove structure to prevent rainsplash and disease spread.

Physical controls for pests deal primarily with insect exclusion. Netting is the best insect exclusion method. The netting used on-farm is ProtekNet insect barrier. On a low



Figure 62. Releasing green lacewing eggs under netting for aphid control on melons.

insect-pressure year, the yearly per-acre cost for netting crops is around 20 percent more expensive than the lowest cost spray program on a per-acre basis. On a high insect-pressure year, the yearly per-acre cost of using netting instead of spraying at a higher per-acre rate is around 20 percent less expensive. Therefore, in an average year, the per-acre annual cost of using netting versus spraying for the target pests is almost equal.

Row covering is another exclusion method, but most row covers provide thermal warming that may trigger premature plant bolting. The warming effect of row cover is sometimes preferable to aid in germination while also protecting the crop from insects. For example, row covers are frequently used over cucumbers that are direct seeded into plastic mulch beds. The cucumbers thrive in the warmth and are protected from cucumber beetles when they are small.

When netting is not used for insect exclusion, aluminized plastic mulch is integrated into the production system as an alternative pest management component. When netting is used, the reflective mulch is not needed.

Every covered crop is uncovered and cultivated at least two times during the crop's growth. In addition, some crops require pollinators. Pollinators need to be introduced when both male and female flowers are identified on the plant. Plants are scouted twice a week for flowers. Pollinators are introduced in one of three ways:

1. Pollinator boxes can be purchased and placed under the nets. This allows the nets to stay on but keeps the pollinators close to the target plants.
2. The nets can be removed entirely for two weeks.
3. The two field ends of the nets can be folded back and opened for two weeks, which keeps some pest coverage but allows for a controlled number of pollinators to find their way into the crops.

Option 2 is the simplest if the fields also need to be cultivated.

The crop netting protocols at UK-CSA indicate the correct covers for the major crop pests, but many more insects will be controlled for a given mesh size beyond those listed. See the [Row Covering and Netting Crops](#) section of the UK-CSA SOP Manual for instructions on covering crops.



Figure 63. Chemical applications made with a Penn's Creek Manufacturing 25-foot boom sprayer.

Table 10. Crop netting protocols.

Crops	Target Pest to Exclude	Maximum Mesh Size	Net Weight per m²	Remove for Pollination?
Brussels Sprouts, Broccoli, Cabbage, Cauliflower, Collards, Kale	Harlequin Bug	1.9 mm x .95 mm	60 gram	No
Arugula, Asian Greens, Baby Kale, Bok Choy, Eggplant, Napa Cabbage, Mustards, Turnips	Flea Beetle	.6 mm x .9 mm	47 gram	No
Cantaloupe, Pumpkin, Winter Squash	Cucumber Beetle, Squash Bug	1.9 mm x .95 mm	60 gram	Yes
Basil	Japanese Beetle	5 mm x 3 mm	55 gram	No
Blackberries, Raspberries	Spotted Wing Drosophila	.85 mm x 1.4 mm	70 gram	No ¹

¹While berries may benefit from pollinators, at UK-CSA these crops are part of a You-Pick operation, therefore bee boxes are not introduced into the picking areas. Pollination continues to be consistent even without introducing pollinators.

The last insect and disease control method is chemical. Some chemical controls are reliable in organic systems, but consideration is always given to the other methods prior to chemical control. In addition, chemicals are rotated to prevent resistance. Examples of insect chemical control include *Bacillus thuringiensis* (Bt) targeted to kill caterpillars like imported cabbage worm, armyworm, and corn earworm; spinosad as a lethal agent for Colorado potato beetle larvae; insecticidal soap for suffocating aphids; and kaolinite clay as a feeding deterrent for cucumber beetles.

Chemical controls are applied by various methods. In small plots or for isolated plants, a backpack sprayer is sufficient. For large acreage, a boom sprayer is used to go over tops of plants. Timing and coverage are critical. Some products degrade quickly in sunlight and must be applied after dark. Other products are only effective when contact is made or active feeding is taking place. Sprays are never to be done when wind speed is above 10 miles per hour. Applicators receive pesticide applicator licenses from the Kentucky Department of Agriculture.

Larger pests, including mammals like mice, voles, groundhogs, and rabbits, beset some areas at the farm. Deer are not an issue. An integrated approach for control includes exclusion, trapping, and attracting natural predators. Owl and bat boxes are one way to attract natural predators to keep mammalian pest populations down. Boxes are hung about 15 feet off the ground, facing east.



Figure 64. Barn owl box on tree near crop fields.

Harvest

Refer to [Harvest Management](#) section of the UK-CSA SOP Manual and the full [Crop Handbook](#) for detailed individual harvest guides.

During the CSA season, harvest occupies a large percentage of labor during the work week. The majority of harvest occurs the day before and the day of the CSA distribution, which at UK-CSA is on Wednesdays and Thursdays. However, crops dictate harvest practices, which may extend harvest to four or five days a week in peak times.

Harvest timing may shift to accommodate weather patterns. Some crops cannot be harvested in wet conditions. These include basil, beans, garlic, bulb onions, popcorn, potatoes, and sweet potatoes. At other times, crops can be harvested wet, when necessary, but should be avoided to reduce disease transmission. These crops include eggplant, tomatoes, peppers, cantaloupe, cucumbers, and squashes. If crops do get wet, they are dried with clean towels or fans are used to blow air over the bins to hasten drying out.

Some crops can be harvested when wet and may benefit from the moisture, as it will keep them cooler than when dry. These include leafy greens, broccoli, green onions, leeks, and sweet corn.¹⁷

Crops are cleaned as much as possible in the field to leave behind residue and soil rather than bringing it into the packing shed, where soil is destined to be washed off and trimmings are discarded. Peeling layers off some crops is one method of cleaning during harvest. This practice is useful for onions (green and bulb), garlic, leeks, head lettuce, bok choy, and cabbages. Another practice is to trim leafy material from tops, stem ends, and roots while in the field. Top-leaf trimming is done in the field for onions, garlic, leeks, kohlrabi, ginger, and turmeric, as well as carrots, beets, radishes, turnips, and rutabaga when greens are not used for bunching. Stem trimming is done in the field for bunched chard, collards, kale, basil, cel-

ery, asparagus, dill, and cilantro. Root trimming is done in the field for kohlrabi, onion, garlic, leeks, ginger, and turmeric.

Many vegetables will cause filled harvest bins to be quite heavy. Harvesting efficiency relies upon minimal handling of produce to reduce bruising, which can compromise storage life, and carrying heavy bins only the minimal distances necessary. The hydraulic conveyor eliminates carrying heavy bins of produce in many cases. When bins are heavy, two people can each carry a side to bring to the field edge or the wagon. All full bins are carried the shortest distance to the field's edge. The harvest wagon can circle the field to pick up all the bins. When bins are left in-row, such as in a summer squash field, workers can walk together in the same direction down the field rows and pass bins from right to left or left to right, until they are handed off to a worker on the harvest wagon.

Some crops are culled during harvest in the field. Factors that determine when to cull a crop include:

- presence of soft spots, rot, juicing, yellowing, or misshapen appearance (e.g., individual cucumbers with poor pollination, kale leaves with yellowing and browning edges, bruised tomatoes or tomatoes with splits that leak fluid, or white cauliflower with black spots of *Alternaria* on surface)
- presence of animal or bird feces on plant (e.g., bird droppings on a kale plant require the entire plant to be skipped and culled later)
- presence of insect infestation (e.g., many aphids on the underside of a kale leaf or a European corn borer hole and frass on the outside of a corn ear)
- the dropping of a crop on the ground that does not normally come in contact with the soil (e.g., tomato, pepper, or broccoli)

When crops are culled, they are removed from the field interior. They are placed in a cull bin and moved to the compost pile, or items are tossed into drive rows outside of the field. This ensures any potential pathogens on a culled crop do not spread readily to neighboring crops.



Figure 65. The harvest conveyor can carry filled buckets or individual crops.

Post-Harvest Handling and Storage

See the [Packing Shed Management](#) section of the UK-CSA SOP Manual for full wash line and packing shed operation details.



Figure 66. Interior of packing shed.



Figure 68. Cooler 2.



Figure 67. Cooler 1.



Figure 69. Cooler 3.



Figure 70. Harvested crops sit on pallets or roller conveyors.



Figure 71. Pallet jacks maneuver macro bins and stacked pallets in the packing shed.

Maintaining good crop quality requires care in harvesting as well as care in handling after harvest. Once the produce arrives at the packing shed, a few basic protocols are followed in keeping with food safety considerations. Crop bins are never set on the floor directly. They are always set atop a roller conveyor, a dolly, or on poly floor pallets. Four to five stacks of bins can be loaded on a 48-inch-by-40-inch floor pallet, or a single stack of bins can be loaded on a 15-inch-by-24-inch plastic minipallet. Floor pallets are maneuvered using a pallet jack, while the minipallets are moved using a custom hand truck with forks.

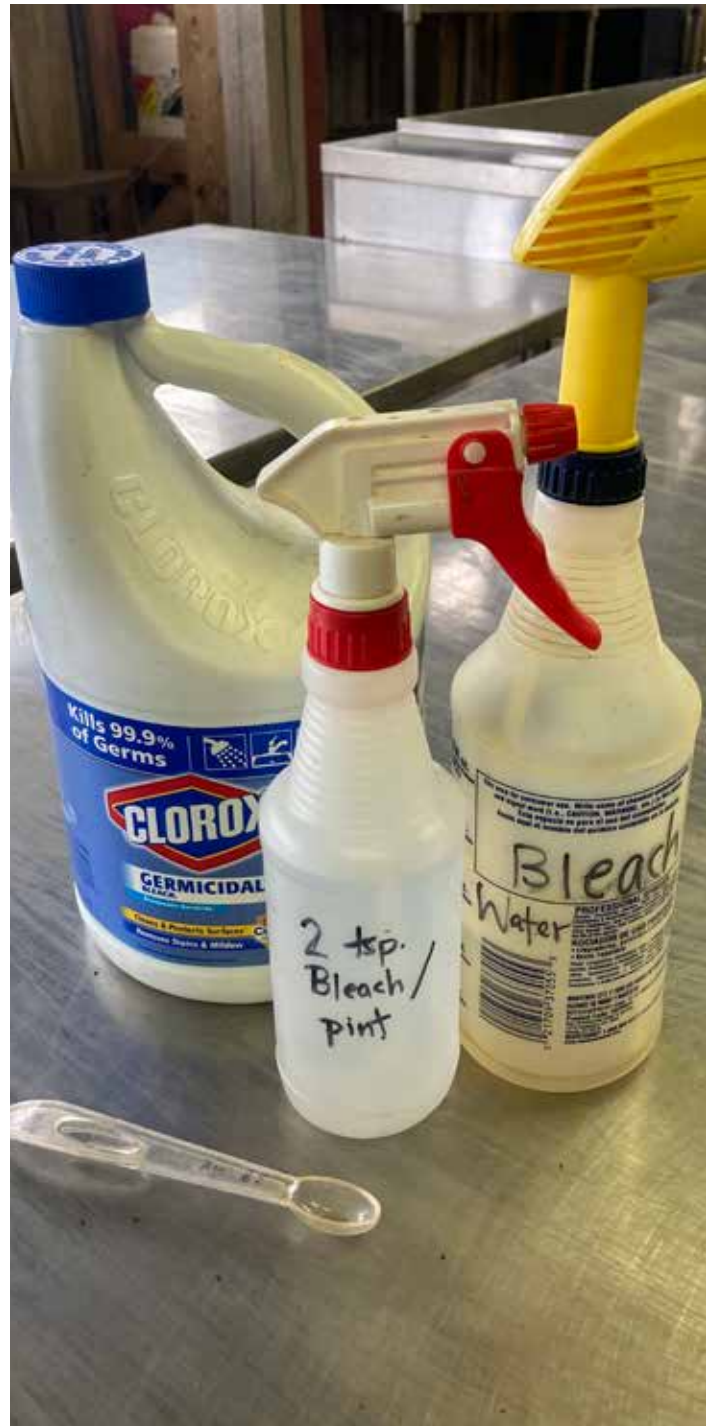


Figure 72. Germicidal bleach solution is used for tool and surface disinfection.

Product flow from doorway to cooler ensures no cross-contamination after washing. After washing, crops are always handled using clean and sanitized stainless-steel tables that are never contaminated with unwashed produce. If tables become dirty, they are sprayed down with water, scrubbed, and squeegeed to remove water. The tables are then sprayed with a final 10 percent bleach solution, which air dries, for disinfection.

Table 11. Crop storage environment selection guide.

<i>Crop</i>	<i>Temperature</i>	<i>Cooler</i>
Asparagus	32°F	1
Beets	32°F	1
Bok Choy	32°F	1
Broccoli	32°F	1
Brussels Sprouts	32°F	1
Cabbage	32°F	1
Cantaloupe	36°F	1
Carrots	32°F	1
Cauliflower	32°F	1
Celery	32°F	1
Chard	32°F	1
Cilantro	32°F	1
Collards	32°F	1
Dill	32°F	1
Fennel	32°F	1
Garlic, storage	32°F	1
Ginger, baby	32°F	1
Kale	32°F	1
Kohlrabi	32°F	1
Leeks	32°F	1
Lettuce	32°F	1
Onions	32°F	1
Parsnips	32°F	1
Peas	32°F	1
Radishes	32°F	1
Rhubarb	32°F	1
Rutabaga	32°F	1
Spinach	32°F	1
Sweet Corn	32°F	1
Strawberries	32°F	1
Turmeric, baby	32°F	1
Turnips	32°F	1

<i>Crop</i>	<i>Temperature</i>	<i>Cooler</i>
Beans	45°F	2
Cucumber	50°F	2
Eggplant	50°F	2
Peppers	50°F	2
Potatoes	50°F	2
Pumpkin	50°F-55°F	2
Summer Squash	41°F-50°F	2
Sweet Potato	55°F-60°F	2
Watermelon	50°F-70°F	2
Winter Squash	50°F-55°F	2
Tomatoes	55°F	3
Basil	Ambient	Pack Shed
Garlic, seed	Ambient	Pack Shed

Records of harvest amounts are essential for tracking crop yield and determining CSA amounts for each member. All harvest amounts, whether by count or by weight, are recorded prior to moving them into storage.

Optimal storage temperatures differ by crop (see **Crop Storage Environment Selection Guide**).¹⁸ At UK-CSA, there are three cooler units that are adjusted to different temperatures. The main cooler is at 32°F to 34°F for all crops requiring a cold environment. The second cooler is kept at around 50°F for crops like potatoes, winter squash, summer squash, peppers, and eggplant. The third cooler is predominantly used for tomatoes and is kept at 55°F, but it is used for smaller amounts of summer squash, eggplant, winter squash, and potatoes when Cooler 2 is full of macro bins. Some crops, like garlic, do not require cold storage. Other crops, like sweet potatoes, are only moved into Cooler 2 for long-term storage. For full post-harvest handling and storage guidelines by crop, see the [Crop Handbook](#).

Season Extension

See [High Tunnel and Solar Greenhouse Management](#) section of the UK-CSA SOP Manual for more information on using two of the four types of season extension structures.

While the main season of the CSA itself is late May to middle of October, the growing season can be extended by producing crops earlier in the spring and later into fall. The spring season relies on use of covered growing environments like high tunnels. Season extension efforts are focused on fall crops, with an eight-week fall program that runs from late October until late December. Fall CSA shares also rely upon storage crops and value-added items like dried garlic and turmeric, as well as fresh items from both field and tunnel. To keep crops alive through temperature fluctuations in late fall, winter, and early spring, row covers are a key tool for successful season extension.

Row covering is used primarily to protect crops from wind and cold temperatures; however, they will also exclude pests. During the heat of summer, row covers are not recommended for pest exclusion, as temperatures under the covering can rise quickly and trigger premature bolting of the plants. Row covers can be time-intensive to set up and cumbersome to take down for weed management.

A summary of crop winter hardiness for Kentucky zone 6b is given in the Winter Vegetable Killing Temperatures chart.¹⁹ Referencing Table 12, row covers are chosen for crops based

on crop location (field or protected in a high tunnel) and thermal protection needed. The thinnest covers of 0.55 ounces per square yard (Agribon 19) will have adequate protection against wind and light frosts, providing two to four degrees of thermal buffering. Midweight covers of 0.9 ounces per square yard (Agribon 30) can be used in a wide array of situations and will give four to six degrees of thermal buffering. The heavy-weight covers of either 1.5 ounces per square yard (DeWitt Supreme) or 2.0 ounces per square yard (Agribon 70) should only be used sparingly for six to eight degrees of benefit, as they also block more than 50 to 70 percent of light transmission. Consult the Row Covering Protocols for Below Freezing Temperatures table. Tunnels on their own can provide two to three degrees of protection, but in a properly inflated, double-layered high tunnel with minimal wind gaps, there may be closer to five degrees of buffering.

Heavier row covers of 1.5 ounces per square yard or more should always be used with hoop supports. Lighter covers of 0.55 to 0.90 ounces per square yard can float on top of plants inside tunnels, but in the field, hoops will keep the covers from touching the leaves, where points of contact can cause freeze damage.

Row covers need to be weighted on all four sides when placed over crops in the field. See the [Row Covering and Netting Crops](#) section of the UK-CSA SOP Manual for more information.

Table 12. Winter vegetable killing temperatures. Adapted from Pam Dawling, Storage Vegetables for Off-Season Sales, 2017 Slideshare

<i>Outside Temperature Lows</i>	<i>Crops Affected</i>
35°F	Basil
32°F	Beans, Cauliflower heads, Corn, Cucumbers, Eggplant, Melons, Okra, Peppers, Potato vines, Squash vines, Sweet Potato vines, Tomatoes
27°F	Fresh Cabbage
25°F	Napa Cabbage, Dill, Fennel, Mustards and Asian Greens (Bok Choy, Tokyo Bekana, Mizuna included), Green Onions
22°F	Arugula, Lettuce
20°F	Beets, Broccoli heads, Some Brussels Sprouts, Storage Cabbage, Celery, Parsley, Radishes, Rutabagas, Turnips
15°F	Russian Kale, Kohlrabi, Chard, Cilantro
12°F	Some Beets, Carrots, Collards, Garlic Tops (large), Summer Leeks, Winter Radish
10°F	Sprouting Broccoli, Brussels Sprouts, Some Collards, Tatsoi, Savoy Spinach
5°F	Garlic Tops (small), Some Kale and Leeks
0°F	Chives, Garlic, Vates Kale, Green Onions (Everygreen Hardy White), Parsnips, Spinach

Table 13. Row covering protocols for below freezing temperatures.

Crops	FIELD		TUNNEL	
	Outside Temperature	Row Cover Weight	Outside Temperature	Row Cover Weight
Arugula	22°F	Light/Mid	20°F	Light/Mid
Asian Greens	25°F	Light/Mid	22°F	Light/Mid
Beets	20°F	Light/Mid	18°F	Light/Mid
Bok Choy	25°F	Light/Mid	22°F	Light/Mid
Broccoli	20°F	Light/Mid	N/A	
Brussels Sprouts	10°F	Heavy	N/A	
Brussels Sprouts	20°F	Light/Mid	N/A	
Carrots	12°F	Light/Mid	10°F	Light/Mid
Celery	20°F	Light/Mid	18°F	Light/Mid
Chard	15°F	Light/Mid	12°F	Light/Mid
Cilantro	15°F	Light/Mid	12°F	Light/Mid
Collards	12°F	Light/Mid	10°F	Light/Mid
Green Onions, Evergreen Hardy White	10°F	Light/Mid	0°F	Light/Mid
Green Onions, Parade	25°F	Light/Mid	22°F	Light/Mid
Kale, Other	15°F	Light/Mid	12°F	Light/Mid
Kale, Vates Blue Scotch	10°F	Light/Mid	0°F	Light/Mid
Lettuce	22°F	Light/Mid	20°F	Light/Mid
Napa Cabbage	25°F	Light/Mid	22°F	Light/Mid
Peppers	32°F	Light/Mid	30°F	Light/Mid
Potatoes	32°F	Light/Mid	N/A	
Radish, Winter	12°F	Light/Mid	10°F	Light/Mid
Radishes	20°F	Light/Mid	18°F	Light/Mid
Rutabaga	20°F	Light/Mid	18°F	Light/Mid
Spinach	10°F	Light/Mid	8°F	Light/Mid
Strawberries	20°F	Light/Mid	18°F	Light/Mid
Strawberries	15°F	Heavy or Double	12°F	Heavy or Double
Tomatoes	32°F	Light/Mid	30°F	Light/Mid
Turnips	20°F	Light/Mid	18°F	Light/Mid

Season extension can be managed through different growing environments, in addition to utilizing row covers in field production. There are four types of covered growing environments at UK-CSA that have been used. High tunnels are the standard season extension environment. The high tunnels are walled on all four sides and have a gothic arch roof. These structures are vented by opening end wall doors as well as raising and lowering sidewall curtains. Three of the high tunnels in use can also be moved along rails to allow for crop rotation and cover cropping, as well as managing optimal crop growth windows. Each tunnel is 30 feet by 72 feet.

Example of optimizing crops with movable tunnels: Winter greens can be grown inside a tunnel, and as spring temperatures warm, the tunnel can be moved off the winter greens, which are frost tolerant. The tunnel then covers a new plot for early spring tomatoes.



Figure 73. High tunnel structure.

Caterpillar tunnels are a smaller version of high tunnels. These structures use a single sheet of plastic to cover sides and ends. Roping holds the plastic in place. Ends are tapered into a cone shape and secured at ground level; they can also be modified with doors. Sides can be raised and lowered manually by adjusting the plastic height behind the roping. Caterpillar tunnels are usually shorter in length, narrower, and not as tall as a true high tunnel. They also have presented challenges in windy conditions and are ideally situated in a north-south orientation to mitigate winter wind damage originating most strongly from the south.



Figure 74. Caterpillar tunnel structure.



Figure 75. Haygrove structures.

Haygroves also use roping over a single sheet of plastic, like caterpillar tunnels, but they have no end walls and no side walls. The plastic is secured on top of the plot as a roof-only structure. This structure will not help with season extension unless sidewalls and endwalls are added. This structure cannot withstand snow loads and has collapsed during winter storms. The plastic can be shed to prevent snow-load damage but often cannot be reused after it is removed. The primary utility of a haygrove is protection from rainfall for crops that are more susceptible to water-dispersed pathogens, like peppers and tomatoes.

The fourth covered structure at UK-CSA is a solar greenhouse, also known as a “deep winter” or “Chinese” greenhouse because of its widespread use in Asia. This greenhouse is an experimental design utilizing passive solar energy to heat the

growing environment. The north side of the structure contains two types of walls; one half of the wall is sand held in by panels of corrugated metal and wood framing, while the other half of the wall is comprised of recycled pickle barrels filled with water and painted black. The sand provides greater thermal mass, giving higher temperature peaks, but it does poorly in keeping the heat overnight. The water-barrel wall does a better job of reducing heat spikes during the day and maintaining more heat during low-temperature nights. The solar house is vented through end-wall doors and one curtain to the south. The air temperatures in this growing environment are difficult to manage, and crops that are sensitive to bolting will not do well here in the off-season. The primary use of the solar greenhouse is to grow tropical crops in summer, like ginger and turmeric.



Figure 76. Solar greenhouse planted in ginger and turmeric.

CSA Labor

Labor management at UK-CSA differs from most commercial farms. Due to the focus on education and extension, students are involved with production at intermittent times throughout the year. However, the CSA is not a student-run enterprise; it requires five full-time equivalent (FTE) staff members to manage the program. Only two FTE staff are kept during the winter, while during the main season, several additional part-time staff are hired to help with harvest days. The normal summer harvest crew amounts to six to 10 people at peak times.

Job training as well as continuing education are vital for all staff and for maintaining efficiency. All workers are trained on food safety, worker safety, cash handling, tractor safety, and packing shed management. The breadth of experience is valuable at the outset to ensure multiple people are proficient in various tasks and able to work independently if needed. After staff have been at UK-CSA beyond a season, developing a greater depth to their skillset and knowledge is encouraged through continuing education and greater focus on specific production elements as part of their staff responsibilities.

CSA Membership

Member management encompasses several areas. Terms and conditions for CSA membership are revised annually. Terms and conditions are important in preparing members for what it means to take part in a CSA, as well as logistics covering payments, missed pick-up policies, and you-pick protocols. CSA benefits and risks are outlined in the terms and conditions. Reading and agreeing to terms and conditions is required prior to CSA registration. Members also receive a handbook at the start of the season. The handbook covers best practices for storing vegetables and shelf life for different crops. Tips on preservation are also included. Engaging members not only during the season but also on the off-season is part of the marketing strategy to increase retention. Engagement occurs through blog posts, weekly or biweekly emails with farm updates and farm stand sale announcements, and frequent social media posts on Instagram or Facebook. Members are also valued for their input, which is solicited at the end of the season through a member-only survey.

At the conclusion of every CSA season, the CSA box value is tabulated based on retail market price. CSA membership is not advertised as discounted produce; however, CSA membership provides added value that members would not receive when buying items a la carte. In addition, members benefit from the surpluses on-farm, which help to offset any risks. Every year, the final dollar value of the share varies, but overall, it has consistently met or exceeded the up-front purchase share price. Box values for the season are averaged. There are certain weeks when the value may be lower than the weekly costs, but this is also countered by bountiful midsummer weeks when the value is much higher than base cost. This variability is inherent based on seasonality of produce and availability of high-dollar-value items. Looking at the weekly box value average, keeping it at no more than 15 percent above retail price is the target at UK-CSA.

In addition to the value of the share itself, CSA members experience added value to their shares through the community aspects of CSA. Members receive electronic newsletters with farm news and recipes tailored for that week's share contents. On-farm you-pick is a highlight for many members. At UK-CSA, a third of an acre is dedicated for you-pick options for members and their families. Crops in you-pick include those that are less desirable to be hand-harvested by the crew (e.g., cherry tomatoes and okra), as well as crops that are desirable for members and have long production. The you-pick crop options include blackberries, raspberries, cherry tomatoes, hot peppers, specialty peppers, tomatillos, green beans, kale, okra, flowers, and herbs. A final way for community building occurs through on-farm events, like potlucks.



Figure 77. You-pick field is a benefit for CSA members.

CSA Marketing

Due to the connection to the University of Kentucky, the UK-CSA program is not advertised outside of the institution. All of the CSA members are current UK staff, students, faculty or alumni, or they are connected to the program through one of the former. UK-CSA is one of the five founding farms to participate in the Kentucky Farm Share Coalition's voucher program in partnership with the University of Kentucky's Health and Wellness group. Since 2015, current employees on a UK health care plan are eligible to receive \$200 as a taxable benefit to apply to the organic CSA program of their choice. Preliminary results indicate improved health outcomes for participants, particularly for new CSA members who were in an at-risk health bracket.²⁰ In addition, CSA members reduced doctor visits and pharmacy expenditures as a result of CSA participation. There have been over 2,585 vouchers dispersed through UK Health and Wellness from 2016 through 2021, and 645 of these vouchers were applied to the UK-CSA program.

Customer retention is a challenge for all CSA producers. Barriers to retention include educating consumers adequately in preparation for membership in a CSA, market-driven choices of farms, and changes in members' life circumstances. Retention percentages have varied year to year at UK-CSA in part due to changes in membership numbers. The current member retention percentage at UK-CSA is 60.4 percent. In addition, 10 percent of current members are non-consecutive repeat subscribers, having let their membership lapse for one or more gap years before joining again. Therefore, repeat subscribers of UK-CSA from both consecutive and non-consecutive years make up 70.4 percent of the total membership. As a point of comparison, a study in 2015 of more than 300 CSA farms in the Midwest found average retention rate to be 46.1 percent.²¹ A second study of 80 CSA programs in California found a mean retention rate of 62.9 percent.²²

Certifications

USDA GAP

In 2015, UK-CSA began to sell wholesale products to UK Dining, and later to Aramark as the food service provider for the University of Kentucky. As a part of this process, a few crops grown at the Organic Farming Unit underwent USDA third-party Good Agricultural Practices (GAP) audit and certification. To become GAP certified, upgrades were made to OFU facilities and harvest procedures, including the addition of a harvest conveyor, installation of a floor trench drain in the packing shed, installation of battens on exterior walls, and the addition of doors to every entrance of the uninsulated pack shed. A significant part of this process was also the development of a comprehensive [Food Safety Manual](#) for the entire OFU. The total investment of materials and estimated labor costs for the GAP upgrades amounted to \$21,155.26, funded in part externally by the Food Connection at UK. UK-CSA passed the GAP audit in 2015, 2016, and 2018. After trialing wholesale market channels, the UK-CSA shifted focus solely onto CSA marketing as a better return on investment. However, the food safety guidelines are still followed as outlined in the UK-CSA [Food Safety Manual](#).

USDA Organic

While some GAP-specific recordkeeping is no longer needed, the UK-CSA maintains thorough records in keeping with organic certification. A full Organic System Plan (OSP) is submitted annually. Accompanying documents include records of seed and live plant material orders and associated organic certificates, planting records, field plans, field activities, compost and manure applications, soil tests, harvest records, shared equipment usage and cleaning records, pesticide spray logs, and lists of all inputs. Certification is handled through the Kentucky Department of Agriculture (KDA) and inspections are conducted annually.

Beyond the Farm Gate

UK-CSA is atypical in the farming landscape; it exists within a land-grant institution, which means the university's tripartite mission of extension, education, and research infuses the work around the farm. While running a successful CSA program is one outcome of this work, the focus is around elevating the broader farming community, educating consumers, and investing in the next generation of producers, particularly in sustainable and organic production. UK-CSA welcomes thousands of visitors to the farm each year: students who learn from hands-on activities, farmers for field days, and community members for tours. In addition, CSA members and their families also occasionally volunteer their time in the fields with the CSA staff. Finally, UK-CSA also gives back by donating extra and "seconds" produce to a non-profit organization called GleanKY for redistribution to food banks and shelters.

UK-CSA Crop Handbook

How to Use the Handbook

The Crop Handbook contains profiles for most of the crops grown at UK-CSA. Some crops are grouped together due to similarity in management. Each profile follows a similar format.

Crop Name.

The crop featured on the profile is listed in the header at the top. Below the crop name, the crop family is listed.

Varieties.

The crop profiles offer an overview of varieties grown successfully at UK-CSA. Comments on varieties and their planned days to maturity are provided.

Greenhouse Production.

Those crops grown in a greenhouse will include their seeding dates, tray size, potting-up requirements, and the number of weeks required to grow in their trays. If the crop is direct seeded, this section will be omitted.

Field Preparations.

Field preparations include any specific considerations addressed before the plants go in the ground. All bare-ground plants will have two lines of subsurface drip tape installed prior to planting and will be cultivated with the stale seedbed cultivator three times prior to planting. With crops grown on plastic, the type of plastic mulch used is indicated. All plasticulture crops are grown with one line of drip tape per bed, and any fertilizer required will be applied at the time of plastic mulch installation, using Nature Safe 10-0-8. Any crop grown outside of the standard two systems will be discussed in further detail.

Direct Seeding.

All direct-seeded crops are seeded on bare ground or in biointensive areas. Earliest and latest seeding dates are given. The settings for the MaterMacc vacuum seeder or the Jang push seeder are given. Fertilizer requirements are noted, as Nature Safe 10-0-8 will be applied at seeding for all bare-ground production crops.

Transplanting.

Any crop grown as a transplant will either be planted on bare ground with the Mechanical Transplanter 5000, planted on plastic with the Rain-Flo water wheel setter, or hand-planted. Equipment settings, plant spacing, and earliest and latest planting dates are noted. The fertilizer requirements using Nature Safe 10-0-8 are included for any plant in bare-ground production.

Cultural Practices.

This section considers the variations in management that make each crop unique. Specific weed problems, pest issues, or disease pressures are addressed. Netting or covering requirements are discussed, along with any protocols that diverge from normal production. Any changes to the standard weed-control methods are also included.

Harvest.

Individual profiles discuss indicators for crop readiness, tools to use for harvest, harvest techniques, and any other pertinent details.

Yield.

These numbers are measured per row foot, averaged from the prior year's average and current year's actual harvest data. In addition, amounts of each crop that are handed out to CSA members are also noted, along with frequency.

Post-harvest Handling.

This section discusses how all crops are brought in from the field and handled in the packing shed. This includes the wash line(s) they require, sorting, and packing protocols.

Storage.

All crops have optimal temperatures to prevent any cold damage. Best storage environment and estimated shelf life is included in this section.

CROP HANDBOOK: ASPARAGUS

Family: *Asparagaceae*

Varieties

Asparagus varieties grown are Millennium, Jersey Supreme, and Purple Passion.

Field Preparations

Asparagus is planted in bare ground, one row per bed.

Transplanting

Asparagus crowns are hand-planted in early April. Beds are spaced four feet apart on center. Trenches are made with furrowers on the back of a tractor-mounted toolbar. Each trench is around 12 inches wide, and crowns are planted at an eight-inch depth. In-row spacing between crowns is 12 inches, therefore 100 crowns are planted in each row in the plot, which is 100 feet long. The roots of the crowns are split and spread in two directions inside furrow. Crowns are covered with only two to three inches of soil at planting. Crowns are then covered gradually on a weekly basis as they grow, until the entire furrow is filled in with soil.

Fertility requirement is 150 pounds of nitrogen per acre during establishment. Fertilizer is split with 75 pounds of nitrogen per acre added in the furrow at planting, and the remaining 75 pounds of nitrogen per acre added after spear emergence. Compost at 10 tons per acre rate is added in the furrows.



Furrows dug eight inches deep by tractor.



Asparagus crowns are kept moist until planting.



Crowns are spaced out every 12 inches. Roots are spread out in two directions.

CROP HANDBOOK: ASPARAGUS

Family: *Asparagaceae*

Cultural Practices

After planting, woven landscape fabric three feet wide is installed between the rows, leaving around 12 to 18 inches in width for the asparagus row to send spears up and expand growth. Wood chip mulch is placed on top of the row for weed control.

The asparagus plot can be mowed once in late summer, in August, to get rid of weeds and any weed seed heads. The plants will rebound and grow up again before overwintering.

In the winter, around late March, all asparagus residue is mowed to the ground. The woven landscape fabric is removed one side at a time and pulled back for flail mowing with the BCS walk-behind tractor. The fabric is reinstalled with sod staples, and then the opposite side is pulled back to mow the next row.



Asparagus can be mowed once in late summer for weed control.



Beds are mulched in-row, and landscape fabric is installed between rows.



Fabric is folded back so that overwintered ferns and fronds can be flail mowed.

CROP HANDBOOK: ASPARAGUS

Family: *Asparagaceae*



Asparagus spears are harvested when they are eight to 10 inches tall.

Asparagus is fertilized after the harvest period annually, requiring 50 to 75 pounds of nitrogen per acre. When applying compost, four pounds of nitrogen per acre can be subtracted from the annual fertilizer needs for every ton of compost applied. With a 10-ton-per-acre compost application rate, only 10 to 35 pounds of nitrogen per acre will be needed each year after establishment.

Hand-weeding and hoeing is needed several times during the growing season after spring harvest.

Harvest

No asparagus spears are harvested the first year they are planted. In the second year, spears are harvested for two weeks. In year three, harvest lasts for four weeks. In all years following, harvest continues for six to eight weeks.

Spears are harvested when eight to 10 inches tall and should have tight spear heads. A serrated knife is used to cut individual spears at the base. The knife should not dig into the soil so as not to damage any new spears beginning to emerge. Spears are placed in red harvest buckets until brought to the packing shed.



Asparagus spears are harvested into bins or buckets.

When in season, spears are harvested daily, if possible. Harvesting every other day is also sufficient.

Yield

As of 2021, asparagus is still in the establishment phase and yield has not been tracked.

Asparagus is a spring item only, as it matures prior to the start of the main CSA season.

Post-harvest Handling

Asparagus that is harvested in red buckets is either dunked or washed on the rinse conveyor. Spears stand upright in clean red buckets and the buckets are set inside larger tote containers with one inch of water at the base to keep cut ends fresh. Spears are banded in one pound bundles with a rubber band tied about four inches above the cut ends. Ends are aligned even if the spear tips are slightly different heights. Purple and green varieties can be mixed. Bundles are placed into smaller containers or five-gallon buckets with one inch of water to transport.

CROP HANDBOOK: ASPARAGUS

Family: *Asparagaceae*



Spears are bundled and then placed upright in containers with an inch of water at base.

Storage

Asparagus is stored at 32°F. Plastic covers are placed over bins for moisture retention.

Asparagus can last two to three weeks in the cooler.



One-pound asparagus bunch.

CROP HANDBOOK: BEANS

Family: *Fabaceae*

Varieties

Green bean varieties for mechanical harvest include Momentum, Caprice, Greenback, and Cosmos. Varieties are chosen for a one-time harvest, producing a concentrated pod set suitable for harvesting with the Pixall bean harvester. Caprice does not set beans well in heat, so this variety is the first variety seeded in cooler conditions.

Specialty varieties include Roma II, Navajo, or Furano (flat pod); Carson (yellow wax); and Tohya or Chiba Green (edamame).

Productive varieties for you-pick that do not require a concentrated pod set include Jade and Provider.

Green beans mature in 53 to 56 days from seeding.

Dry beans are not grown due to their labor-intensive post-harvest handling requirements of winnowing. In addition, dry beans are not easily harvested mechanically, as dry pods will shatter. Dry beans may be included in the you-pick field.



Beans on the plant ready to harvest.

Direct Seeding

Green beans are seeded using the MaterMacc vacuum seeder. Seed plate 72, 4.5 is used, and in-row spacing is two inches, which on the MaterMacc are sprockets 22-22. *Note: These sprockets are not the same if using the MaterMacc VegiMacc vacuum seeder. The MaterMacc VegiMacc can be used as a backup, but beans seeds can become clogged due to their large size.*

The MaterMacc seeder is driven no faster than 2.0 miles per hour to prevent clogging. The chutes from the bean hoppers are monitored to ensure the beans are flowing freely.

Earliest recommended seeding is April 25, and latest is July 25. Seeding date is calculated to correspond to a Tuesday or Wednesday harvest prior to the CSA distribution date on Thursday.

5,000 seeds are allotted per bed, or 2,500 per row.



Beans are direct seeded with the larger of the two MaterMacc vacuum seeders.

CROP HANDBOOK: BEANS

Family: *Fabaceae*

Field Preparations

Beans are grown on the bare-ground system. No fertilizer inputs are required for beans.

Cultural Practices

Plants are monitored for Mexican bean beetle larvae and adults, and leafhoppers. In order to disrupt pest patterns, each bean planting is seeded into its own field, rather than side by side. Bean plantings are moved around the farm and isolated geographically for maximum pest disruption. Timely sprays of Pyganic, Entrust, or Neem can knock back Mexican bean beetle larvae, but contact is required for efficacy. All bean plantings are situated on the outer edge of the field to accommodate harvesting with the Pixall bean harvester.

Beans are basket weeded after germination, and finger weeded until plants begin to flop over and send out tendrils. Beans are not aggressively finger weeded, as this causes too much soil to build up around the plant stems. Immediately prior to harvest, field edges are mowed and workers hand-pull or scuffle hoe any larger weeds by walking the rows.

Harvest

All beans other than you-pick varieties are harvested using the Pixall BH100 Bean Harvester. If beans are planted on the eastern edge of a field, the field is entered with the harvester from the north. If beans are planted on the western edge of a field, the field is entered with the harvester from the south.

Beans must be dry before harvest. Ideally, harvest begins around 10 or 11 a.m., after the morning dew has evaporated.

Two people are required to harvest beans. The driver runs the Pixall harvester on the Kubota 9540 or the Kubota 5030. The 9540 is run in the snail 5 gear and 540 PTO. The 5030 is run in the medium gear range and 540 PTO. Maximum ground speed is 0.75–1 mph. Faster speeds cause pod breakage. Ear plugs are worn when operating the Pixall harvester.

The second worker drives a truck to the field with stacks of dark green or blue bins to catch the beans. The truck is parked out of the way of the harvester in the opposite drive row or at field ends past the bean rows themselves. The worker sets up eight bins on the back of the harvester: one under each of the two chutes, and six stacked upside down under the fan blower. The worker rides on the machine and monitors the harvest.



Beans are seeded two inches apart, and about one half-inch deep. This is how they would look under the soil surface.



Mexican bean beetle adults. In larval stage, they are bright yellow.



After germinating, beans are basket weeded.

CROP HANDBOOK: BEANS

Family: *Fabaceae*



The Pixall BH100 Bean Harvester captures bean plants in a pair of tines that funnel plants into the picking reel.

The front tines of the harvester guide the bean plants into the rotating picking reel. The bean stem should be within one inch of the outside tine. The hydraulics raise and lower the tines. The tines themselves should barely scrape the soil surface or ride along just above the soil surface. The worker on the back monitors the chutes for any rocks, debris, or soil. If any soil comes into the bins, the worker gives the stop hand signal to the driver and indicates to move the machine up higher. When harvest resumes, the worker on the back switches the chute once field soil is no longer being pulled into bins, to keep the next beans from mixing with those in the soiled bin. Bins weighed down with soil are set aside for sorting and cleaning in the packing shed.

If plants or soil is exceedingly wet as a result of a recent rain, the machine will not operate successfully. In these situations, green beans must be harvested by hand or not at all. Workers pull the entire plants and strip individual pods off the stems into red buckets. Two red buckets are nested in each other at an offset to close the side gaps, preventing harvested beans from falling out the sides. Workers are discouraged from sitting on buckets during harvest, as this will slow down the process.



The second worker monitors beans coming out of the chute and switches the chute when one side is full.



Only stems remain in the field after harvest.

CROP HANDBOOK: BEANS

Family: *Fabaceae*



When rocks or debris come into the harvest bin, as at left, the worker in the field or on the back of the machine gives the driver the sign for “stop” with a closed fist, shown at right.



Clean beans ready to bag. Beans may still have smaller stems attached.



Flat pod beans, also referred to as “Roma” type.



Bagged beans for CSA share. Bag top is twisted or folded down for packing.

Yield

Bush green beans can yield 100 pounds per 300-foot bed, or 0.25 to 0.35 pounds per row foot.

Since acquiring the mechanical harvester, green beans are now included in CSA shares four to six times a season. For at least one or two weeks, the shares will include a specialty bean, like flat pod, yellow wax, or edamame. Each share distribution includes approximately one and a half to two pounds of fresh green beans. Flat pod beans are heavier and the share amount may be closer to two to two and a half pounds of flat pod beans.

Post-harvest Handling

All beans are weighed as they come into the packing shed. Any beans in bins with dirt are sorted into a clean, dark green bin before being weighed. Washing beans is avoided as it compromises storage life. On the rare occasion that beans become excessively muddy during a wet harvest, the barrel washer is used to rinse beans. Beans are spun in the Greens Machine salad spinner to remove as much moisture as possible. Spun beans are placed in dark-green bins and allowed to drip-dry overnight before bagging. Beans are not bagged more than one day in advance if washed.

Some small bean stems are acceptable when bagged, as not every bean is plucked cleanly from the plant. The larger plant stems and debris (rocks or leaf matter) are pulled out before bagging beans. Some beans will be broken. Large broken beans are kept, while small bean pieces are discarded. Beans with excessive scarring from bean beetle feeding damage are also discarded, while a small scar is tolerated. The bean-sorting process inside the pack shed will take four to six workers working for two hours at a minimum. When yield is high, beans can be sorted more quickly by focusing on the larger, cleaner beans to put in the bags.

Green beans are bagged in clear plastic bags, and tops are twisted or folded over to close. Bags are stacked in dark-green bins in two to three layers, with seven to 10 bags in each layer. Weightier bags will result in fewer bags per bin.

Storage

Beans are optimally stored in the cooler at 40°F to 45°F, but they can be stored at 32°F to 34°F without chill injury. When beans are loose, plastic pallet covers are not pulled over the bins until the end of the day to minimize field heat condensation. When beans are already bagged, no plastic covers are needed over the bins. Beans are distributed within one to two days.

CROP HANDBOOK: BEET AND SWISS CHARD

Family: *Amaranthaceae*

Varieties

Beet varieties grown include Red Ace, Red Cloud, Cylindra, Moneta, Chioggia Guardsmark, and Touchstone Gold.

Beets mature in 45 to 55 days from direct seed.

Swiss chard varieties grown include Bright Lights in the main season, and Peppermint in winter.

Swiss chard matures in 55 to 60 days for bunching size from direct seed.

Greenhouse Production

Both beets and chard are seldom grown as transplants. However, for biointensive plantings, they are seeded in 162-cell Winstrip trays four weeks prior to target transplant date.

Field Preparations

Both beets and chard are grown on bare ground. Both can be grown intensively in fields or tunnels.

Direct Seeding

Chard is seeded at four-inch in-row spacing. This spacing is for larger, bunching sized leaves.

Beets are direct seeded at in-row spacing of 1.5 inches. They are thinned to three inches after germination.

MaterMacc VegiMacc plate 96, 2.5 is used for beets, and plate 36, 2.5 for chard. For 1.5-inch spacing on beets, sprockets used are 22-22. For 3.9 inches on chard, sprockets 22-21 are used.

In intensive systems, beets and chard are grown with three rows per bed. Jang push seeder is used with seed roller LJ-12, or the crops are hand-transplanted after being grown in the greenhouse.

Beets require 50 pounds of nitrogen per acre, while Swiss chard requires 125 pounds of nitrogen per acre. All fertilizer is banded at time of seeding.

Earliest seeding date recommended in the field for chard is March 20, and latest is July 15. Beets have a wider planting window: March 15 at the earliest and August 10 at the latest.



Cylindra beets pop out of the ground when they are harvest ready.



Peppermint chard grown in a tunnel.



Beets being hand-planted in a biointensive plot.



Swiss chard leaves at full size for bunching.

CROP HANDBOOK: BEET AND SWISS CHARD

Family: *Amaranthaceae*

Cultural Practices

Neither chard nor beets have many troublesome pests. *Cercospora* leaf spot is common for beet leaves. This is mostly cosmetic damage. Roots are sometimes attacked by aphids. Flea beetles may also be an issue at certain times. Chard is more vulnerable to grasshoppers, which can take large bites out of leaves.

Beets and chard are cultivated with the basket weeder and finger weeder, before beets have enlarged. Beets are also hand-weeded in order to thin them to a wider spacing. Thinning is optimally done soon after germination.



Workers clean and bunch beets.

Harvest

Beets are harvested selectively for the largest roots. Roots are three to four inches in diameter when ready to be harvested. The *Cylindra* variety is more slender, around two inches in diameter, and elongated. *Cylindra* roots will push themselves up and out of the ground as they mature and become harvest ready. Roots are pulled out of the ground with their greens attached. Piles of beets are made in-row for cleaners and bunchers to follow behind the harvesters. For largest beets, only three to a bunch is sufficient. Bunches with medium to smaller beets will include four to six total beets. Brown, torn, and damaged leaves are removed by hand. Beets are gathered together and secured with a rubber band or twist tie at the lowest part of the leaves, closest to the top of the root. Bunches are stacked upright in harvest totes. Beets can be harvested a day or two in advance of distribution.

After the first harvest, subsequent harvests are made weekly as the other remaining beets mature in size. No more than three harvests are made from a given planting before all beets will be cleared out. In the second and third harvests, all greens are removed using a small, serrated knife. Only a quarter inch of stem should be left attached to the beet root. Greens are left in the field, and roots are loaded into harvest bins.

Chard is also selectively harvested, ideally on the day of distribution. Individual stalks are removed from the plants, starting with those leaves that are the largest. Chard leaves are harvested when the leafy part above the stem is at least six inches in length. Some leaves will be over a foot long. Leaves with many tears, holes, or similar issues are removed from



Examples of five-, four-, and three-beet bunches, based on size.

CROP HANDBOOK: BEET AND SWISS CHARD

Family: *Amaranthaceae*



Beets pulled for bunching, with Cylindra at left and Chioggia at right.



Banding chard leaves on their stems close to the leaf base.



A twist tie holds the bunch together as harvesters continue to pick leaves.

the plants and discarded. In this way, the plants are cleaned during the harvest process. All leaves should be gathered in hand with the lower leaf margins in alignment. This allows for tighter, cleaner bunching. A rubber band or twist tie secures the bunch at the top of the stem, closest to the leaf base. Each bunch should contain six to 10 leaves, depending on size of leaves. After bunching, a lettuce field knife is used to trim the bottom stem ends to make them even. Bunches are packed upside down into harvest totes.

Yield

Beet yield varies by variety. Red beet average yield is 0.85 pounds per row foot, while the specialty types of gold and Chioggia yield around 0.57 pounds per row foot.

Beets are given out as bunches one or two times and then as roots only two or three more times. Members receive one bunch, or one to two pounds of roots, for each distribution.

Swiss chard yields 0.3 to 0.4 bunches per row foot. It is given out in CSA shares five or six times, and it is sometimes a choice item with other bunched greens like kale. Members receive one bunch of chard at each distribution.

Post-harvest Handling

Beet bunches are washed using the bunched washing station. Bunches are packed into light- or dark-green bins, in alternating layers.

Any beet bunches not delivered or sold will have their greens removed. All beet roots are washed using the barrel washer. Beet roots will be packed into light-green bins and weighed.

Chard bunches are washed in the dunk tank with the bubbler. Bunches are checked for leaf quality. Greens are packed and counted into dark-green bins in alternating layers.



Bunched beets are washed on the bunched washing station.

CROP HANDBOOK: BEET AND SWISS CHARD

Family: *Amaranthaceae*



Beet roots are washed in the barrel washer, then sorted and weighed.



Touchstone Gold beets bunched for a CSA share.



Bunched Red Ace beets with greens.



Bunched Bright Lights chard.

Storage

Beets and Swiss chard are stored at 32°F. Plastic pallet covers should be placed over the bins to retain moisture. Swiss chard is good for 10 to 14 days in the cooler. Beet roots without greens will store for three to five months or more.

CROP HANDBOOK: BOK CHOY AND NAPA CABBAGE

Family: *Brassicaceae*

Varieties

For bok choy, smaller types like Mei Qing Choi are preferred.

For napa cabbage, a smaller head like Minuet is grown.

Napa cabbage and bok choy are fast growing, maturing in 45 to 50 days from transplant.

Greenhouse Production

Bok choy and napa cabbage are seeded into 128-cell Win-strip trays. These crops will be in the tray for four weeks prior to planting.

Field Preparations

Napa cabbage and bok choy are transplanted into bare ground in the field system. In the biointensive systems, plants are grown in three rows, and two lines of drip tape are laid on top of the bed at planting.

Bok choy requires 125 pounds of nitrogen per acre, while napa requires 150 pounds of nitrogen per acre. All fertilizer is applied at planting.

Transplanting

Plant spacing varies by production system. Bok choy and napa cabbages are planted at nine inches in the field with the Mechanical Transplanter planter.

Both bok choy and napa cabbage can be grown in biointensive systems at six-inch in-row spacing with three rows per bed. At the six-inch spacing, bok choy and napa cabbage will be hand-planted.

Earliest planting date in central Kentucky is March 25, and latest is July 31. While bok choy and napa cabbage can be grown in tunnels for overwintering, they do not hold very well and will bolt readily in spring.



Mature bok choy, ready to harvest.



Napa cabbage has a defined interior head with a few outer leaves that may be loose.

CROP HANDBOOK: BOK CHOY AND NAPA CABBAGE

Family: *Brassicaceae*

Cultural Practices

Flea beetles are a major pest of both bok choy and napa cabbage. Plants are covered with 47-gram ProtekNet insect netting at the time of transplanting. Hoops are used to keep the net from touching the plant leaves and deter any feeding through the net.

Crops are basket weeded and finger weeded in the field, which requires moving the net and hoops. In biointensive plots, crops are scuffle hoed or hand-weeded as needed.

Harvest

Bok choy and napa cabbage are best harvested using a lettuce field knife or a harvest machete.

For napa cabbage, harvest readiness is checked by lightly pressing down in the top center of the head. There should be resistance where the leaves have developed and curved to form a rounded top. If the top is very loose, it needs more time to fill out the head.

Heads are harvested at the base of the plant, near where the stem meets the soil. The knife is positioned parallel to



Rounded top of a napa cabbage head is firm when pressed with fingertips.



Bok choy are gently nestled upside down into a bin.

CROP HANDBOOK: BOK CHOY AND NAPA CABBAGE

Family: *Brassicaceae*

the soil surface and sliced through the stem. Workers take care not to dig the knife into the soil during harvest, as this can create a buildup of dirt on the blade, particularly in wet soil conditions.

For bok choy and napa cabbage, it is critical to cut at the correct height. If the plant is cut too high, the head will fall apart as loose leaves. If the head is cut too low to the ground, it may necessitate a second trimming cut. The cuts should be flush and even. Place bok choy and napa cabbages vertically in bins, with cut ends facing up. Aim for 12 heads or more per bin for maximum bin efficiency. Bok choy leaves can easily crack, so they are handled gently. To place gently in bins, position hands around the leaves as the head is nestled into the bin, keeping leaves pointed in the same direction to prevent bending and breaking.

Yield

Napa cabbage yields 0.8 to 0.95 heads per row foot. Bok choy yields 0.75 to 1.0 heads per row foot.

In CSA shares, bok choy and napa cabbage are specialty crops that are given out only one or two times a year. Bok choy and napa cabbage are fast growing and provide good options for quick greens to diversify leafy greens in CSA shares.

Post-harvest Handling

Bok choy and napa cabbage heads are washed in the dunk tank. A bubbler helps to agitate leaves in case any insects are at the base of leaves. Heads are firmly shaken upside down when removed from the tank. The heads are counted and placed on their sides or upside down into dark-green bins to encourage water drainage.



Bok choy is washed in the dunk tank and packed on their sides in dark-green bins.

CROP HANDBOOK: BOK CHOY AND NAPA CABBAGE

Family: *Brassicaceae*



Both napa cabbage and bok choy can be laid on their sides in bins, or packed upside down.

Storage

Bok choy and napa cabbage are stored at 32°F. Bins are covered with plastic after being set in stacks inside the cooler.

Bok choy is best distributed within a few days but may last up to 14 days in the cooler. Napa cabbage can store in the cooler for two months. Some outer layers of leaves will need to be peeled when yellowing occurs in longer term storage.

CROP HANDBOOK: BRAMBLES, BLACKBERRY, AND RASPBERRY

Family: *Rosaceae*

Varieties

Blackberries grown are Osage, which is an erect variety, and Triple Crown, which is a semi-erect variety.

Raspberries grown are Prelude, which is a thorny, summer-bearing variety with medium to large berries. It will produce both a summer and a smaller fall crop. The second variety grown is Joan J, which is a thornless primocane variety, bearing fruit on the first year's canes in the early fall. Berries are large and firm.

Field Preparations

The bramble patch was spaded and cultivated prior to installation. Compost was applied at 10 tons per acre rate. Soil tests were done to confirm that the pH was between 5.5 and 6.5.

The brambles were established under a Haygrove system. The Haygrove plastic over the bramble plot aids in cane establishment. In the third year, the plastic from the Haygrove system was destroyed in an ice storm. No change in plant vigor and production has been observed since the loss of the plastic.

Brambles require 50 pounds of nitrogen per acre rate at planting and annual applications during dormancy in February or early March. The rate of nitrogen may need to increase beyond 50 pounds per acre, reaching up to as much as 150

pounds per acre in the following years if plant vigor is reduced. Indicators of plant stress include shorter and thinner canes and foliage that begins to yellow.

Transplanting

Berries are purchased as bare-root plants and planted in early May. Raspberries are spaced 24 inches apart in-row, and blackberries are spaced 36 inches apart in-row. Bare-root plants are hand-planted, using a tape measure to keep accurate spacing in-row. Irrigation drip tape lines are laid on top of the soil next to the berry plants. Rows are spaced six to eight feet apart.

Cultural Practices

After planting, strips of woven landscape fabric are installed with sod staples in between the rows of the brambles. Each row of brambles is allocated a row 12 to 18 inches across for canes to emerge. The landscape fabric defines the growing area, helps to control canes from spreading beyond the planted zone, and controls weeds.

Wood mulch is applied in-row. Mulch can be reapplied annually as needed, to help with weed control.

Brambles require a trellis. Each trellis post is constructed out of a metal T-post, spaced between 15 and 25 feet apart



Bare-root canes are hand-planted with a measuring tape for proper spacing.



Berries are established in a plot with landscape fabric between rows and mulch in-row.



Berry trellis component is made of a metal T-post with two crosspieces and a PVC tee at the top to lift the net above the plants.



A Max Tapener handheld tying machine secures canes to the wires as they grow.

CROP HANDBOOK: BRAMBLES, BLACKBERRY, AND RASPBERRY

Family: *Rosaceae*



Old floricanes are pruned to the ground and removed.

in row. The T-posts are fitted with metal crosspieces at three feet and five feet high. The lower crosspieces are 18 inches long, while the upper crosspieces are 24 inches long. Crosspieces are held tight to the T-posts with U-bolts and nuts. An 11-gauge wire runs through the crosspieces, secured in notches on top of the crosspieces. The wires create a lower and an upper channel for the canes to grow up into, forming the shape of a V. The wires are angled down at each plot end and secured to an anchoring T-post installed into the ground at a 45-degree angle, away from the plot. Each anchoring T-post is connected by 11-gauge wire to a helical soil anchor for stability. Each wire is wound on a ratchet-style wire tensioner. Over time, the wire may need minor adjustments to keep it taut as it holds more weight from the canes. As the canes begin to grow, they are tucked inside the trellis wire and secured to the wire when they are small, using a Max Tapener handheld tying machine.

Brambles require pruning in late winter or early spring. If the canes are beginning to push out new leaves, the canes should be pruned soon. Mid-March is a general target time for pruning. Both raspberry varieties are pruned at the same time, which gives two crops for Joan J instead of just one in the fall. The raspberry floricanes are cut down to the ground and removed. The remaining canes are thinned to four canes per row foot, or eight per plant. The canes are also cut back to about four feet in height. When thinning, remove the skinniest canes.

Blackberries are pruned similarly. All woody floricanes are removed. Remaining canes are thinned if needed, re-



All canes are topped to four-foot height.



Blackberry laterals, shown here, are trimmed to 18 inches.

CROP HANDBOOK: BRAMBLES, BLACKBERRY, AND RASPBERRY

Family: *Rosaceae*



The bramble patch prior to pruning.



The bramble patch after pruning.

moving the smallest canes or those spreading to the edges of their planting zone. At least three to six healthy canes are left per plant foot. All canes will be cut back to four to five feet. Blackberries also have many side shoots, called laterals. Laterals are trimmed to 12 to 18 inches. Any damaged canes are removed entirely.

Netting with 70-gram ProtekNet netting, rated for the spotted wing drosophila (SWD), is essential for high-quality berries. Once the berries are beginning to color, the net is pulled over the plants. PVC pipes are trimmed and attached to PVC tees on top of the T-posts holding the trellis. The netting is laid atop the PVC tees. Two large nets are sewn together to create a single net to fit the berry plot, which is 100 feet long by 25 feet wide. Enough netting is given to reach all the way to the ground on all four sides. On the long sides, the net is held down with pavers spaced every five to 10 feet. On the end with the trellis anchors, sections of pool noodles are fitted over the wire tensioners to prevent snagging and tearing of the net. The net is tied shut on the anchor ends with thread or fishing line and clipped with large binder clips to keep it closed and secured.

The plot is monitored to ensure no animals, like birds, get under the net and become trapped. If any bird becomes trapped under the net, one of the sides is opened so the animal can be released safely.

While netting may exclude pollinators, pollination has never been an issue, even with the netting in place.

Once the harvest season is complete, the netting is removed and stowed over winter until the following season.



Two large pieces of ProtekNet netting are sewed together using a handheld sewing machine. Photo courtesy of Gonthier Lab.



ProtekNet netting is weighted to the ground with pavers.



Netting covers the entire berry plot overhead and on all sides for protection from spotted wing drosophila and harvest ease.

CROP HANDBOOK: BRAMBLES, BLACKBERRY, AND RASPBERRY

Family: *Rosaceae*

Harvest

Berries are harvested by hand into pint- or quart-sized Berigard molded-fiber berry boxes. Ripe berries will come off the plant when tugged lightly. If they do not come off readily, they are not ripe. Berries are part of the UK-CSA you-pick and are not harvested for inclusion in weekly CSA shares. Daily or every-other-day harvest is best when berries are in season. Frequent picking by CSA members keeps the plants productive, and few berries are lost to overripening.

CSA members are instructed on harvesting technique and reminded to ensure the netting stays weighted down after harvest. Wearing gloves may be desired when harvesting from thorny varieties like Prelude. For marketable fruit, it is critical to ensure minimal damage during the harvest and post-har-

vest stages to maintain the fruit's firmness. Pick berries directly into the final container that will be given out or sold to minimize handling or number of touches on the delicate berries.

Yield

Overall yield is not tracked, since the brambles have been in production as part of a you-pick operation.

Post-harvest Handling

Berries are not washed on-farm.

Storage

Berries are best stored at 32°F and should be consumed within three to five days.



Ripe blackberry.



Ripening raspberries.



A CSA member you-picks ripe raspberries.

CROP HANDBOOK: BROCCOLI AND CAULIFLOWER

Family: *Brassicaceae*

Varieties

Broccoli varieties grown in spring are Belstar, Gypsy, Green Magic, and Lieutenant. Imperial is grown in early summer and fall. Other fall broccoli varieties grown include Emerald Crown and Belstar. Arcadia and Marathon do well in the latest planting windows.

Earliest broccoli matures in 56 days from transplant, while later varieties take up to 68 days.

Cauliflower varieties grown include Bishop, Denali, Flamestar, and Steady. The only romanesco variety grown is Veronica.

Cauliflower matures in 50 to 78 days from transplant.

Greenhouse Production

All broccoli and cauliflower are seeded into 128-cell Win-strip trays. Most will be in the tray for four weeks. Any greenhouse broccoli and cauliflower started in midsummer will do best under misters for better germination.

Field Preparations

Both broccoli and cauliflower are grown in the bare-ground production system. On occasion, in order to get an early start, they are transplanted into plastic mulch. However, they risk overheating prior to maturity.



Broccoli plants are grown in a large quantity to meet CSA expectations.

Transplanting

Broccoli is planted with 12-inch in-row spacing. Cauliflower requires 18-inch in-row spacing.

Earliest recommended planting date for central Kentucky is April 5, and latest is August 1.

Broccoli requires 100 pounds of nitrogen per acre, while cauliflower is a heavier feeder, needing 150 pounds of nitrogen per acre. Broccoli will get all fertilizer applied at time of transplanting, but cauliflower receives two-thirds of the nitrogen requirement at planting and one-third from fertigation after eight weeks of growth.

Cultural Practices

The most common insect pest pressures for broccoli and cauliflower are aphids during warm spells, imported cabbage worm, cutworm, flea beetle, and harlequin bug. Plants transplanted in the summer for fall production are covered with 47- to 60-gram ProtekNet netting to protect from the harlequin and the flea beetle. Timely sprays of *Bacillus thuringiensis* (Bt) will keep worms in check.

White cauliflower will turn yellow from sun exposure unless it is blanched. To blanch the heads, two or three of the leaves surrounding the interior head are broken at the mid-



Example of a cauliflower with partial self-wrapping.

CROP HANDBOOK: BROCCOLI AND CAULIFLOWER

Family: *Brassicaceae*



This white cauliflower will be best covered by breaking adjacent leaves over top to protect it from yellowing.

rib and flopped over top of the head. This can be done by workers walking the field and snapping leaves for one row at a time. This only needs to be done when plants are not good at self-wrapping the heads and the white heads are beginning to be revealed at the plants' centers. Since this discoloration is a larger issue in the spring, non-white varieties are grown to avoid the need for blanching, with white cauliflower being grown primarily in fall.

Harvest

All broccoli and cauliflowers are best harvested using a lettuce field knife or a harvest machete.

Cauliflower is harvested below the curds, and the closest wrapper leaves are kept attached. Harvest starts when the heads are between five and six inches across. Some varieties will go up to 10 inches and may weigh as much as four pounds each. Romanesco is a specialty type of cauliflower that forms cylindrical heads with fractals like miniature seashells, exhibiting a Fibonacci sequence. This cauliflower does best in fall and is harvested at a slightly smaller base diameter, starting around four inches. It is difficult to see where the base of the head lies, as many of the lower leaves curl underneath the head. Some smaller leaves are retained, but workers cut heads lower initially and then trim them, until they become familiar with this crop's growth pattern.



Broccoli are not harmed by dew and can be harvested wet.



When florets loosen, harvest if the head is at least the size of a fist.



Romanesco cauliflower is a stunning fall favorite.

CROP HANDBOOK: BROCCOLI AND CAULIFLOWER

Family: *Brassicaceae*

Broccoli, when harvested as a crown, is cut close to the florets. However, most broccoli is harvested with a longer stem attached. The harvest knife is placed four inches below the crown and cut cleanly through. Several leaves may still be attached. The largest, lowest leaves are removed by hand, and two or three smaller leaves are left attached. Broccoli needs to be harvested a minimum of twice a week when in season. The florets must be tight, compact, and have full color. Once florets become enlarged and loosen, the head is past its prime. In addition, heat stress can cause uneven development, with some florets being taller than others, giving an uneven appearance to a usually smoothly rounded head. This will not improve over time, and the head should be harvested without delay. Heads that are beginning to loosen are ideally at least the size of a fist. If smaller heads must be taken due to heat stress, the smaller heads are bundled together for an amount equivalent to a normal head.

Broccoli occasionally exhibits a hole in the middle of its stem. This hole can indicate a boron deficiency, boron uptake deficiency, or a nitrogen surplus. If a soil test indicates boron is less than one pound per acre for the field, additional boron may be needed. Otherwise, the hole may be from nitrogen. The hole in the stem does not usually cause rot, but fruits are inspected at harvest and discarded if any secondary rot occurs.

Some purpling discoloration may occur on broccoli heads during cold weather due to inhibition of phosphorus uptake, but the head is not harmed.

Broccoli harvest can be done quickly with a conveyor, with a worker walking each aisle and checking two rows of plants on either side to harvest. Broccoli can also be harvested in pairs, with one person cutting while the second follows behind, carrying the bin until full.

Yield

Cauliflower average yield is 0.3 to 0.6 heads per row foot. Broccoli yields 0.65 to 0.8 heads per row foot. Romanesco yields on average 0.3 to 0.45 heads per row foot.

In CSA shares, broccoli is a staple crop and is given out for two to four weeks in early summer and two to four weeks in fall. Cauliflower is a specialty crop that is given out only one or two times a year. Cauliflower is one of the more challenging brassicas to grow, in large part because they are in the ground for so long and it is risky to try to plant them early enough to have them ready before the CSA season ends. They are much more reliable for later fall and are great crops for Thanksgiving, particularly romanesco types.



A hole in the stem may indicate a boron deficiency.



Broccoli is harvested efficiently with a conveyor.



On the harvest wagon, broccoli is packed into bins for transport to the packing shed for washing.

CROP HANDBOOK: BROCCOLI AND CAULIFLOWER

Family: *Brassicaceae*

Post-harvest Handling

Cauliflower and romanesco are not washed. They are counted and packed into light-green bins with only two layers.

Broccoli is washed in a dunk tank. A bubbler will help to dislodge any insects hiding underneath the florets or in the branching stems. In warmer months, broccoli will benefit from an ice bath for better cooling. Broccoli can also be top-iced, but a plastic barrier under the ice may be desired; ice can also be added to the bottom of the bin instead. Direct con-

tact between melting ice and broccoli florets can cause water-soaking of the tissues. Broccoli is counted and loaded into light- or dark-green bins.

Storage

Broccoli and cauliflower are stored at 32°F. Bins are covered with plastic to trap moisture.

Broccoli has a storage life of about seven to 10 days, while cauliflower may hold in storage for up to three weeks.



Broccoli harvested when warm is dunked in an ice bath.



Broccoli is harvested with four-inch stems for CSA shares.



Cauliflower and romanesco can be harvested with a few of their closest wrapper leaves still intact.

CROP HANDBOOK: BRUSSELS SPROUTS

Family: *Brassicaceae*

Varieties

Brussels sprouts used for earlier harvest include Jade Cross and Franklin. Later-maturing varieties grown include Divino and Diablo. Jade Cross does not respond well to pinching.

Early-maturing varieties are ready in 85 days, and longer varieties may take 100 to 120 days, both from transplant.

Greenhouse Production

All brussels sprouts are seeded into 128-cell Winstrip trays. They are grown for four weeks before transplanting.

Field Preparations

Brussels sprouts are transplanted into bare-ground fields.

Transplanting

Brussels sprouts are spaced in-row at 23 inches, with two rows per bed.

Brussels sprouts need 150 pounds of nitrogen per acre, which is partially applied at time of planting. Since they are a long-season crop, a third of their nitrogen requirement is supplied by fertigation after eight to 10 weeks of growth.

Cultural Practices

Brussels sprouts are susceptible to many of the same pests year after year. The most common are aphids during warm spells, imported cabbage worm, cutworm, flea beetle, and harlequin bug. The harlequin bug is the primary pest of brussels sprouts and may attack the earliest fall plantings the most. Brussels sprouts are covered with 60-gram ProtekNet netting immediately after planting. Later plantings of brussels sprouts will also benefit from netting. Harlequin bugs feeding on leaves can weaken the plant defenses and may exacerbate disease issues. Hoops are placed over plants to keep the net from



Harlequin bugs cause significant damage. Feeding pressure coupled with heavy rains were optimal conditions for *Alternaria*.

Netting protects crops, but white chlorosis on leaf is evidence of harlequin bugs feeding through the net.

CROP HANDBOOK: BRUSSELS SPROUTS

Family: *Brassicaceae*

touching the surface, as harlequins may still feed through the netting when it is in contact with the leaf surfaces. As plants grow, they will eventually touch the net when regular wire hoops are used, but by then damage is minimized.

During wet periods, *Alternaria* can become a significant disease issue. Chemical sprays of Bt control the cabbage worms, and insecticidal soap controls the aphids.

Nets are removed periodically to allow for two cultivations with the finger weeder, and then the nets are replaced.

Harvest

Brussels sprouts are harvested in two different ways. Sprouts can be left on the stalk with a single, whole-stalk harvest, or the sprouts can be pulled off the stalks individually. If desiring a full stalk, it is important to encourage even development of all the sprouts by removing the apical meristem, which is the growth point at the top of the plant. Simply twist the tip of the stem off the plant by hand at a minimum of four weeks prior to intended single-cut harvest. Most sprouts benefit from five to six weeks after pinching for full-stalk development.

When it is time to harvest, leaves are stripped off the stalks of any that are ready to take. Either a leaf-stripping crew is sent down the rows first, with a cutting crew following behind, or stripping and cutting is done at the same time by one person. Stripping helps to identify which plants are ready and streamlines the cutting stage. To strip, simply grab leaves and pull down. Plants can also be “karate-chopped,” with arms moving down the plant on either side to break all the leaves.



Stalks are roughly stripped of leaves in preparation for cutting.



Harvesters follow cleaners and position tobacco machete below the last sprout to cut.



Pinching off the top of a brussels sprout plant for full-stalk harvest.

CROP HANDBOOK: BRUSSELS SPROUTS

Family: *Brassicaceae*



Stalks are kept vertically in bins, or they are piled into a macro bin until being counted in the pack shed.

When ready to cut, harvest machetes or tobacco knives are used to slice the thick stems off at the base. The stalks are very thick and may require two or three cuts to separate them from the roots. It is important to make sure knives have been sharpened prior to harvest. Cut stalks are stacked upright in harvest totes. Full totes are moved to the packing shed, or they can be emptied into a clean macro bin for counting and storing.

To harvest individual sprouts, do not remove the growth point. Sprout harvest is a preferred method when desiring to get multiple harvests off the crop, or when desiring to overwinter the plants. Start with the mature, rounded sprouts at the bottom and work your way up. Simply pull down on each sprout with a slight twist to separate and collect individual sprouts in a harvest bin. Be sure that the sprouts cannot fall through any holes or slits in the bins.

Yield

Brussels sprouts yield 0.15 pounds per row foot for early harvest, or 0.5 stalks per row foot for late harvests.

In CSA shares, brussels sprouts are a specialty crop that are given out only one to two times a year. Brussels sprouts are the most challenging brassica to grow, in large part because they are in the ground for so long, and it is risky to try to plant them early enough to have them ready before the CSA season ends. They are much more reliable for later fall and are great crops for Thanksgiving.



Snapping off individual sprouts is a different harvest technique.

CROP HANDBOOK: BRUSSELS SPROUTS

Family: *Brassicaceae*

Post-harvest Handling

Brussels sprouts are not washed unless necessary.

Brussels sprout stalks are hard to pack and stack. If stalks are short or can be split in half, they can be counted and stored in dark-green bins. Taller stalks can be held upright in harvest bins or dark-green bins, but they will not be stackable. Large amounts of stalks can be stored easily in a macro bin. Individual sprouts can be held in yellow bins or weighed into quart containers that are lined up in yellow bins.

Stalks are tabulated by count, while loose brussels sprouts are tabulated by weight.

Storage

Brussels sprouts are stored at 32°F.

Bins should be covered with plastic to trap moisture. However, a large macro bin of brussels sprout stalks will give off significant field heat and should not be covered until end of day or the following morning after harvest.

Brussels sprouts will hold in the cooler for two weeks or more.



Loose sprouts are kept in yellow bins. They are weighed into quart-sized berry containers.

CROP HANDBOOK: HEAD CABBAGE

Family: *Brassicaceae*

Varieties

Various head-cabbage varieties are grown, including Farao, Bronco, and Storage No. 4 (green heads); Omero, Red Express, and Ruby Ball (red heads); Famosa (savoy); and Caraflex (conical).

Early head cabbages like Farao and Caraflex mature in 65 days, while main-season or storage-cabbage varieties like Bronco, Storage No. 4, and Famosa mature in 85 to 95 days, all from time of transplanting.



Clockwise from top left: Storage No. 4, Red Express, Caraflex, and Famosa

CROP HANDBOOK: HEAD CABBAGE

Family: *Brassicaceae*

Greenhouse Production

All cabbages are seeded into 128-cell Winstrip trays. They are ready after four weeks of growth.

Field Preparations

Cabbages are transplanted into bare ground.

Transplanting

Head cabbages are spaced 16 inches apart in-row.

Head cabbages require a total of 150 pounds of nitrogen per acre. Two-thirds of the fertilizer requirement is applied at planting, while the final third will be fertigated after eight to 10 weeks of growth.

Earliest planting date in central Kentucky is March 25 and latest is July 31 for cold-tolerant savoy types.

Cultural Practices

Head cabbages are susceptible to *Alternaria* and insect pests like aphids, imported cabbageworm, cabbage looper, and harlequin bugs. When possible, head cabbages are covered with 60-gram ProtekNet netting at time of planting.

Plants are cultivated with the basket weeder and finger weeder until heading begins.

Harvest

Cabbages are best harvested using a lettuce field knife or a harvest machete.

Cuts are made at base of head but above the loose, wrapper leaves. If the heads are intended for long storage, keep several wrapper leaves intact. If heads will be handed out immediately, only a single wrapper is sufficient. Push back extra wrapper leaves to make the head more visible and easier to cut.

Inspect heads for worm and bug damage; frass can be seen at the base of the wrapper leaves. Tunneling may indicate a pest has burrowed inside, in which case successive layers can be torn off to remove any yellowed area. A pest hidden below the top layer may be too far down to make the peeling worthwhile. If a few layers are peeled off the cabbages, a second cleaning cut on the stem may be needed to keep it flush with the head. The stem should not extend past the last layer of leaves more than one-eighth inch.



Head cabbages during an extremely wet season experienced harlequin bug pressure and then succumbed to *Alternaria*. The entire crop was a loss.



Worker pushes back outer leaves to get clearer view to cut.

CROP HANDBOOK: HEAD CABBAGE

Family: *Brassicaceae*



Cabbages are tossed from harvester to intermediary to wagon.

Large cabbages are best harvested using a conveyor and loaded into macro bins, or they can be tossed after all the cuts have been made. Tossing cabbages requires three to five people: one worker to drive the tractor, one or two to catch cabbages on the wagon, and one or two to throw cabbages from the field to the person on the wagon. The person on the wagon is responsible for placing them in a macro bin after they are caught. If cabbages are dropped, they are set aside for a cull bin; the force of impact will frequently cause the head to split, even if it is not immediately visible.

Yield

All head cabbages have an average yield of 0.45 to 0.60 heads per row foot.

In CSA shares, head cabbages are given out four to six times a year.

Post-harvest Handling

Head cabbage can be washed on the brush washer or washed directly on the conveyor. For maximum efficiency, the conveyor on the harvest wagon can be angled off the wagon into an open pack shed doorway with a macro bin sitting near the end. Cabbages are unloaded in reverse, from a macro on the wagon onto the belt, moving the cabbages into the packing shed. Using a hose midway up on the conveyor, cabbage heads are sprayed quickly, particularly the cut end, which is usually where dirt may be adhered. After the quick spray,



Savoy cabbages are loaded onto the conveyor at harvest.

CROP HANDBOOK: HEAD CABBAGE

Family: *Brassicaceae*



The conveyor is angled into the pack shed and reversed to send cabbages down the line for a spray wash. Cabbages are then counted and loaded into a clean macro bin.

heads are picked from the end of the conveyor and placed gently into a second clean macro bin. Heads are counted as they are loaded. Smaller head cabbage amounts are counted into dark-green bins.

Cabbages are counted as they are packed in a macro bin, and the final count is recorded with a label on the bin. When counting smaller heads into dark-green bins, only five to 10 cabbages fit inside each bin. Label each bin with the number of cabbage heads per bin when the count is not consistent for every bin.

Storage

Head cabbage is stored at 32°F.

A large macro bin of cabbage will give off significant field heat and should not be covered until end of day or the following morning after harvest. Other bins can be covered with plastic after being set in stacks inside the cooler.

Cabbage can be stored in the cooler for two months. Some outer layers of leaves will need to be peeled when yellowing occurs in longer-term storage.

Storage No. 4 cabbage can hold for six months or longer in proper storage. Keep as many wrapper leaves on the heads as possible. Remove the outer leaves when ready to distribute. A second washing or quick spray may be needed after pulling them out of long-term storage. The cut ends may also need to be trimmed and rinsed.



Leaving more wrapper leaves on cabbage heads prolongs storage in macro bins.

CROP HANDBOOK: CANTALOUPE

Family: *Cucurbitaceae*

Varieties

Athena cantaloupe is preferred for its size, shelf life, and disease tolerance. Fruits are five to six pounds each. Smaller, Tuscan types like Wrangler also produce well.

Cantaloupe matures in around 79 days from transplant.

Greenhouse Production

Cantaloupe is hand-seeded into 72-cell Winstrip trays. Plants require only three weeks in the greenhouse, as they are more vigorous than watermelons.



Athena cantaloupe ready to harvest.

Field Preparations

Cantaloupe is grown on white plastic mulch beds when netted, or aluminized plastic mulch if unnetted. No living mulch is planted. Plastic beds are cultivated several times prior to planting. Each field holds six or seven beds for melons, spaced at least seven feet or eight feet apart respectively.

Cantaloupe requires 120 pounds of nitrogen per acre. Two-thirds of the required fertilizer is applied pre-planting, at time of plastic laying. Cantaloupe is then fertigated with the remaining nitrogen requirement after eight to 10 weeks.

Transplanting

Cantaloupe is transplanted using the water wheel setter, in a single row per bed at 30-inch in-row spacing. They can also be grown at closer spacing, but 30 inches allows for more uniform vining out.

Earliest planting date is May 10, and latest is July 1.

Cultural Practices

Beds are netted with 60-gram ProtekNet netting at time of planting. Plastic beds are cultivated one or two times after planting. The nets are removed and replaced at each cultivation. The final cultivation may require manually moving any vines that have fallen off the bed top back onto the bed. After this final cultivation, the plant is left to grow into the rows and shade out weeds. Nets are removed for pollination for two weeks, once both male and female flowers are present.



Cantaloupe is netted for protection from insects.

CROP HANDBOOK: CANTALOUPE

Family: *Cucurbitaceae*



Green lacewing eggs are released three times after planting, with releases spaced a week apart, to control aphid outbreaks. Plants are misted prior to scattering eggs at dusk.

Cantaloupe is routinely afflicted by aphids when young. Every growing season, three weekly releases of green lacewing eggs are made, starting right after transplanting. Eggs are spread out across all the cantaloupe beds, and plants are misted prior to shaking the eggs around the plant bases.

Many diseases attack cantaloupes, depending on the growing season's climatic conditions. Common issues include powdery mildew, downy mildew, gummy stem blight, and anthracnose. Protectants, which may include *Bacillus subtilis*, *Bacillus pumilus*, neem, and copper, are applied on a 10-day cycle starting in the early growth phase.

Irrigation is withheld in the last two to four weeks of maturation to increase melon sweetness.



These vines are coming off the bed and will be pushed back on top for one final cultivation between rows.

Signs of gummy stem blight on leaves, top, and fruit stem, bottom.

CROP HANDBOOK: CANTALOUPE

Family: *Cucurbitaceae*

Harvest

Cantaloupes are checked daily leading up to harvest. A daily harvest is not possible, therefore they are harvested twice a week, on either Mondays and Wednesdays or Tuesdays and Thursdays, depending on readiness. Cantaloupe is harvested in the field using the conveyor. The conveyor wagon is preset with two macro bins situated on either side of the conveyor prior to being taken to the field. Workers walk in between each bed and check both beds on left and right, as well as the area in between, for melons ready to harvest. Harvest is selective for ripe cantaloupes.

Prior to harvest, one or two cantaloupes are cut open to determine readiness and taste for sweetness. Harvest indicators include size of melon; full development of netting around the melon; color change from green to yellow under the netting; and three-quarters or full slip of the stem. Full slip is when the stem is tugged gently and detaches completely from the fruit, leaving a slightly hollow stem scar. When the stem cannot be removed easily or is broken, leaving some stem tissue attached, the melon is not at full slip. Once harvest begins, workers pay attention to which melons give full slip to determine the ideal melon.



Stem being pulled by hand off of melon.



This cantaloupe was at three-quarters slip, as a small stem residue was left behind on the right side.



This cantaloupe is at full slip.

CROP HANDBOOK: CANTALOUPE

Family: *Cucurbitaceae*



Cantaloupes are harvested by hand and placed on the harvest wagon conveyor belt. Melons are stacked gently into macro bins on the wagon.

Melons are removed from plants by hand, with the stem being gently pulled away from the top of the fruit. Melons are placed individually onto the conveyor. The conveyor will carry the melons to the harvest wagon, and workers place melons into a macro bin. Melons should not be dropped into the bins as they can crack. When field conditions do not require melons to be washed, they are counted at time of harvest by the worker placing them into the macro bins.

Yield

Cantaloupes yield 0.40 fruits per row foot.

Cantaloupes are given out in CSA shares two or three times a year. Each share receives one to two melons per distribution.

Post-harvest Handling

Cantaloupes are not washed unless absolutely necessary due to muddy field conditions. When muddy, they are washed in the brush washer. If washing is not necessary, cantaloupes can be kept in a clean macro bin and moved from the harvest wagon to the packing shed using a forklift, where they are maneuvered into the cooler for room cooling.

Storage

Cantaloupe is optimally stored at 34°F to 38°F. After field heat is removed, plastic pallet covers go over the tops of the macro bins.

Cantaloupe does not store long and is best distributed within two to three days of harvest.



Cantaloupe macro bins are moved using a forklift.

CROP HANDBOOK: CARROTS

Family: *Apiaceae*

Varieties

Spring varieties include Mokum and Yaya . Main-season preferred variety is Romance. Late-season and storage varieties include Bolero, Hercules, and Yaya.

Spring carrots mature in 54 days, main season in around 70 days, and late season in 75 days or more after direct seed.

Field Preparations

Carrots are grown in the bare-ground production system. The stale seedbed cultivator goes over beds three to four times over the course of three weeks prior to planting. Alternatively, instead of the cultivator, the Pyroweeder flame weeder is used weekly over three weeks. The flame-weed method results in less soil disturbance; however, flaming will not kill grasses.

Direct Seeding

Carrots are direct seeded with the MaterMacc VegiMacc. NOP-compliant pelleting on seed is preferred for proper seeding rate. Soil should be friable and loose; carrots seeded on rocky soil or soil with high residue can become stunted or branched.

Carrots are spaced apart 0.8 inches in row, at a depth of 0.25 to 0.5 inches. MaterMacc seed plate 144, 2.5 is used for pelleted seed and sprockets are set to 22-17 for 0.8-inch spacing. For unpelleted carrot seed, MaterMacc seed plate 180, 0.8 is used and sprockets are set to 17-18 for 0.8-inch spacing. A Jang push seeder is used when planting intensively, as in high tunnels. The Jang seed roller used for pelleted carrot seed is LJ-12, at two-inch spacing. Carrots are seeded intensively with three or four rows per bed.

Nutrients can often be provided in large part from the previous cover crops. Carrots require 90 pounds of nitrogen per acre, and fertilizer required is banded at time of seeding. Excessive nitrogen can cause carrot malformations like branching and forking.

If seeding carrots for spring, the earliest seeding date recommended is March 20. The latest recommended seeding date for a fall crop is July 15. If overwintering carrots in a tunnel, ideal planting time is early to mid-September. Ideal soil temperature is 77°F for good germination.



Carrots peeking above soil surface.



Carrots are hand-weeded in-row when plants are small.

CROP HANDBOOK: CARROTS

Family: *Apiaceae*

Cultural Practices

Flame weeding is effective for broadleaf weeds in carrot beds. Carrots are flame weeded weekly prior to emergence. Carrots generally emerge in seven to 21 days. Planting a few beets at the end of the row will be an indicator of when carrots will germinate; once beets emerge, carrots are flamed immediately for the last time as they will emerge only a day or two later.

Seedling germination will be aided by even moisture on the bed top, which also prevents soil crusting. If weather does not have rain in the forecast, sprinklers or drip tape laid on the bed tops is used to hasten germination. The most critical irrigation time is for seedling emergence.

After seedlings emerge, the carrots are basket weeded weekly. Once carrots are taller and more established, a finger weeder may also be used. Some hand-weeding in-row may be required, and wheel hoeing the shoulders and wheel tracks may be needed if soil conditions do not allow for use of tractor implements for cultivation.

Carrots are monitored for pests like cutworms, aphids, flea beetles, armyworms, and whiteflies. Carrot diseases are not a prominent issue, and most issues are mitigated by crop rotation and the allowance of prior crop residues to ful-

ly break down. Carrots are a minimally to zero-sprayed crop at UK-CSA.

Overwintered carrots are row covered when temperatures go below 20°F. Frosts are tolerated, but hard freezes can kill carrots. Some carrots may survive at temperatures as low as 12°F.

Harvest

Carrot size at time of harvest varies by variety. Mokum is generally a smaller carrot of 5.5 to 6.5 inches in length. Romance is seven to nine inches long, and Bolero is seven to eight inches long. Storage carrots can be held in the ground longer as temperatures decrease. Carrots are harvested either by hand with a digging fork or by using a plastic lifter or undercutter implement. If using an undercutter, be sure the implement can get entirely underneath the carrot root without chopping off the tips.

When digging by fork, the fork is placed two to three inches off to the side of the carrot top. The fork is sunk vertically down into the ground as far as it will go. The fork is rocked back and forth a few times to loosen soil profile. Care should be taken in not bending the fork all the way back, as this risks spearing the sides of the carrots. Once the soil is loosened, the



Digging carrots by fork.



Fork is sunk three to four inches from base of carrot, then carrots are hand-pulled and laid on top of soil.



CROP HANDBOOK: CARROTS

Family: *Apiaceae*

fork is pulled out and moved down the row six inches to the next section. Carrots can then be pulled out of the ground by grabbing them close to the base of the green tops where they meet the root. Carrots are piled for bunching or clipping off the greens.

For bunched carrots, six to 12 carrots go in a bunch. Any yellowed or brown leaves are removed by hand. Carrots are bunched using a twist tie to hold greens together tightly. For storage carrots without greens, pruners or a serrated knife are used to cut greens a quarter inch from the root top. Any excess greens will degrade the carrot in storage. Clipped carrots are placed in harvest bins for transport to the packing shed.

Carrots should not be dug and left exposed to the sun on top of the soil for long. Only sections that can safely be clipped or bunched within the hour are dug and pulled at one time.

Yield

Yield average is 0.4 bunches per row foot or 0.4 to 0.75 pounds per row foot. Main-crop and fall-crop carrots have higher yield per row foot, as carrots are larger and soil is warmer at time of seeding.

Desired CSA amount is one bunch weighing around one pound each, or one to two pounds of loose roots, per distribu-

tion. Carrots are a CSA staple crop at UK-CSA. Carrots show up in early summer (two times), late summer (two times), and fall shares (two to three times). CSA members receive approximately 10 to 15 pounds of carrots a season, between mid-June and mid-October.

Post-harvest Handling

Bunched carrots are best washed at the bunched washing station. Loose roots are washed in the barrel washer, and benefit from an extra spray by the hose when getting started if especially coated in dirt. Loose roots are also washed easily in the dunk tank with the bubbler. Bins that are one-half to three-quarters full are placed on top of the bubbler inside of tank. The water level must be above the carrots in the bins once submerged. With bubbler turned on, carrots are left for 10 to 30 minutes. In the dunk tank, six harvest totes can fit inside at one time. Each tote holds about 40 pounds of carrots. After bubbling, a quick final rinse in the barrel washer may be desired, or they can be transferred immediately to a clean light-green bin for storage. Washed carrot roots are weighed prior to storage.

To view video of the washing process, click on the following link:

[Video: Bubbler washing carrots](#)



Bunched carrots washed at bunched washing station.



Loose carrots in barrel washer benefit from extra hose spray.



Barrel-washed carrot roots.

CROP HANDBOOK: CARROTS

Family: *Apiaceae*

Storage

Carrots are stored inside the cooler at 32°F to 41°F. Once the field heat has been removed, the bins are covered with plastic pallet covers on top and down the sides for maximum moisture retention. Carrots without greens can be held in storage for six to nine months. Freeze damage will occur if storage temperatures dip below 30°F.



Six bins of carrots fit in dunk tank for bubbling.



Bunched carrot example for CSA shares.



Carrots washed with dunk tank bubbler.



Loose carrots are bagged in plastic for CSA shares.

CROP HANDBOOK: CELERY

Family: *Apiaceae*

Varieties

Celery varieties used with success include Tango and Merengo. Celery can take up to 100 days to reach maturity after transplanting.

Greenhouse Production

Celery needs 12 weeks in the greenhouse and benefits from potting up during its greenhouse growth. Celery is started in 128-cell Winstrip trays and is potted up to 72-cell Winstrip trays after six to eight weeks.

Transplanting

Celery is best grown under cover in high tunnels. To keep it from getting overheated, it is grown on white plastic mulch. In biointensive management systems, celery is grown with three rows to a bed and nine-inch in-row spacing. For plasticulture

systems, celery is still grown with nine-inch in-row spacing, but with only two rows per plastic bed.

For overwintering in high tunnels, a succession of celery can be started in the greenhouse.

Earliest planting date is mid-May, while an overwintering planting in a high tunnel can be transplanted as late as mid-November. Summer celery is transplanted in the beginning of June for a late-September harvest.

Cultural Practices

Proper irrigation management is critical for celery. However, if plants are exposed to too much rain, crown rot can result. Growing them under cover is the preferred growing method.

A frequent insect pest of celery is spider mites. Watch for yellowing and stippling on leafy tops, after which they can be controlled with an insecticidal soap application.



A healthy celery plug shown in a 72-cell Winstrip tray.



Celery succumbed to crown rot during a wet year when not protected under cover.

CROP HANDBOOK: CELERY

Family: *Apiaceae*

Harvest

Celery can be harvested in two different ways: whole head or individual stalks. Production of whole heads for celery is inconsistent, and celery is only harvested as an entire head as a last harvest at the end of the year. Celery is usually harvested by individual stalks. The very first, outermost stalks are usually leafy and short. Just inside these first outer leaves will be the first good stalks to harvest. The length of each stalk should be a minimum of six inches from base to node, where the leaves begin to split off from the stalk. Ideal stalk length is eight to nine inches. Some stalks can be pulled from the base with a firm tug. Otherwise, use a small knife to make a cut as close to the base as possible. A bunch is made from eight to 12 stalks,

and a rubber band, placed midway up the stalk, holds them together. Care should be taken to not wrap the band too tightly, as this can compress and break the stalks. End of the stalks are trimmed for a smooth, clean cut.

When removing stalks, the cut end is inspected. Browning in the veins occurs when the stalks are older and turning woody. Any stalks with discoloration visible at the base veins are culled. In addition, cold damage can cause the outer skin of the celery stalks to peel off. These stalks are not marketable and are trimmed from the plant.

After harvest, workers continue to remove yellowed, dead, and diseased-looking leaves and plants from the area to allow for successive harvests.



Start cutting celery stalks from the outer base.

CROP HANDBOOK: CELERY

Family: *Apiaceae*



Individual celery stalks banded at harvest.

Yield

Celery has yielded 1.0 to 1.25 bunches per row foot of plants.

Celery is a specialty herb and is only given out one or two times in CSA shares per year. However, as celery does very well in fall and winter, it is also included in fall shares and at spring farm-stand sales.

Post-harvest Handling

Celery is washed as a bunch with the rinse conveyor or hand sprayed on the bunched washing station.

After washing, bunches are counted and stacked in alternating directions in light-green, dark-green, yellow, or other bins. Celery is lightweight and can be stored in numerous bin sizes.



The last harvest of the season can be a whole-head harvest.

CROP HANDBOOK: CELERY

Family: *Apiaceae*

Storage

Celery is kept in the cooler at 32°F, and plastic pallet covers are placed over the bins for maximum moisture retention.



Banded celery stalks can be washed at the bunched washing station.

CROP HANDBOOK: COLLARDS AND KALE

Family: *Brassicaceae*

Varieties

Collards variety grown is Champion. Three primary varieties of kale are grown: Red Russian, Toscano, and Winterbor. Other varieties also grown include Lacinato and Vates for overwintering.

Most brassica greens are ready to start harvesting in 45 to 55 days for mature leaves, which is from transplant.

Greenhouse Production

All kale and collards are seeded into 128-cell Winstrip trays. They will grow for four weeks before transplant.

Direct Seeding

For baby/young leaves, kale is direct seeded at 0.8-inch spacing. See [Crop Handbook: Leafy Greens \(Direct Seeded\)](#) for more information.

Field Preparations

Collards and kale are transplanted in the bare-ground production system.

Transplanting

Kale and collards are planted using the Mechanical Transplanter planter at 12-inch in-row spacing.

Greens require a rate of 125 pounds of nitrogen per acre. All fertilizer is applied at planting.

Earliest date for transplanting in central Kentucky is March 10, and latest for outdoor field production is August 20. Plants can be overwintered with row cover or in a high tunnel. Late-fall plantings are recommended in early September.



Collard and kale transplants in the greenhouse are often easy to identify, even as young seedlings.



Lacinato kale is also known as Toscano, Tuscan, or dinosaur kale.

CROP HANDBOOK: COLLARDS AND KALE

Family: *Brassicaceae*



Cultural Practices

Insect pests, including aphids, imported cabbageworm, cutworm, flea beetle, and harlequin bug, frequently attack kale and collards. The greens are netted with 47- to 60-gram ProtekNet netting when flea beetle and harlequin beetle pressure is strong to maintain blemish-free leaves. Hoops are placed over plants to keep the net from touching the plants, as pests may still feed through the netting when it is in contact with the leaf surfaces. During wet periods, *Alternaria* can become a disease issue and is managed with copper.

Harvest

Kale and collards are harvested by hand, but a lettuce field knife is used in the field for trimming cut ends.

Harvest begins when the plants reach near-mature size, with numerous leaves well developed. The largest leaves are always harvested first, usually on the outer rim of the plant. Leaves are pulled off as close to the base as possible in order to leave plenty of stem for bunching.

Curly kale plants can also be harvested en masse. The plant is faced and both hands are placed on top of the leaves just outside the center growth point. Stems are grabbed at the base and yanked in one downward motion. Workers can easily grab four to eight stems in one motion with this technique.



Crew members harvest kale and collards as individual leaves and then bunch them.

Curly kale is grabbed below the smaller leaves on top, which are left to continue growing. Leaves are torn with two handfuls.

CROP HANDBOOK: COLLARDS AND KALE

Family: *Brassicaceae*



After bunching eight to 10 leaves, ends are trimmed with a lettuce knife.

Collard bunches usually have six to 10 leaves per bunch. Larger kale, like Winterbor and Red Russian, likewise get six to 10 leaves per bunch; smaller leaves, like those of Lacinato, may need 10 to 12 for a similarly sized bunch. Rubber bands or twist ties may be used for bunching. The leaves are all faced in the same direction, and the lower leaf margins are aligned. This will allow the tie or band to be placed as close to the leafy part as possible, leaving a stem below as a handle to grab. Cut ends are trimmed with a lettuce field knife to even the cut end. When placing bunches in the bin, stack vertically with stems pointing up for maximum pack efficiency.

Plants are cleaned during harvest. Any leaves that are yellowing, browning, or have insect damage are removed from the plant and tossed aside. Cleaning the plants reduces disease pressure and makes subsequent harvests easier.

Yield

Kale yields an average of 0.4 bunches per row foot.

Collards also average 0.4 bunches per row foot.

In CSA shares, kale and collards are rotated to provide greens six to eight weeks out of the year.



CROP HANDBOOK: COLLARDS AND KALE

Family: *Brassicaceae*



Bunched greens are washed with the bubbler and then counted into dark-green bins.

Post-harvest Handling

Kale and collards are washed in a dunk tank. A bubbler will help to agitate leaves to dislodge dirt and any insects. These crops are best counted and loaded into dark-green bins. Bunches of greens are laid down flat in bins, with stems pointing to the outside of the bin in alternating layers.

Items are counted, with the number of bunches packed per bin being consistent for every bin. Depending on the size of leaves, 12 to 20 bunches of greens can be packed in a bin at a time.

Storage

Kale and collards are stored at 32°F.

After the wash and pack, bins are covered with plastic pallet covers to trap moisture. Brassica leafy greens can remain in cold storage for 10 to 14 days after harvest.



Bunched Red Russian kale.



Bunched Winterbor curly kale.

CROP HANDBOOK: CORN

Family: *Poaceae*

Varieties

Sweet corn varieties at UK-CSA are sh2, or supersweet types. When other types are grown (synergistic or popcorn, for example), the different varieties are spaced apart at a minimum of 300 feet from one another, or their maturity dates need to be staggered by 12 days or more to prevent cross-pollination.

Sh2 varieties change frequently. Varieties that have done well include Catalyst, American Dream, SS3778R, SS2742, and Xtra-Tender 3473. Popcorn is a specialty corn grown at UK-CSA. Robust Yellow has performed well.

Sweet corn matures in 69 to 77 days. Popcorn matures in 110 days. Both days to maturity are from direct seeding.

Field Preparations

Corn is planted in the bare-ground production system. Since corn is not weed competitive, it is important that fields have undergone three to four passes of the stale seedbed cultivator prior to seeding.

Direct Seeding

Corn is direct seeded using the MaterMacc VegiMacc vacuum seeder.

Seed plate 36, 4.5 is used for all corn varieties. Optimal corn spacing is eight to nine inches in row. However, due to historic variability with germination, earliest corn is seeded at 3.9 inches and thinned to eight to nine inches. The variability is likely the result of cool soil temperatures for the earliest corn plantings. Corn requires a minimum soil temperature of 65°F for good emergence, but optimal temperatures are 80°F to 90°F. Early May seeding does not reliably get these temperatures. By middle of May, soils are reliably in the range of 68°F to 78°F. Therefore, on earliest seedings, check soil temperatures and err on the side of overseeding. When soil temperatures are higher, corn can be seeded at lower density. The MaterMacc VegiMacc sprockets for closer spacing of 3.9 inches are 22-21. For larger 7.8-inch in-row spacing, the sprockets are set at 12-23.

Approximately 10,000 seeds are required for five beds of corn, which is 3,000 row feet when seeded at the closer spacing.

Sweet corn and popcorn all require a nitrogen rate of 120 pounds per acre. All fertilizer required is applied at seeding.

Cultural Practices

When corn is seeded at 3.9 inches, it must be thinned to eight to nine inches. Within a week of emergence, workers walk each row with a scuffle hoe and remove any plants that are too close to achieve the correct spacing. The plants are



Corn is direct seeded with the MaterMacc VegiMacc.



Corn is finger weeded when plants are four to eight inches tall.

CROP HANDBOOK: CORN

Family: *Poaceae*

sliced at the soil surface with a quick back-and-forth motion.

Corn is basket weeded and then finger weeded weekly when it is four to eight inches tall.

Corn needs to be monitored for worm pressure. There are two primary worm pests that impact our sweet corn: corn earworm and European corn borer (ECB). To monitor for these worms, trapping nets are mounted on a T-post at either end of the field starting in May, or when earliest corn is producing fresh silks. Monitoring ceases when fresh silks have dried.

Heliothis traps, made of collapsible mesh with a removable pouch for easy counting of insects, are used. The bottom net opening should be at the same height as the corn silks for

proper trapping. Each net holds a lure for one of the two types of corn pests. For European corn borer, lures for both ECB I NY strain and ECB II IA strain should be used. The lures last around two to four weeks, so swapping out lures for new ones may be needed. Workers wear a new pair of nitrile gloves when handling each lure to prevent any cross contamination between lures. The net trap is checked one or two times per week for pest pressure.

When the earworm or borer moths are being caught, the crops will benefit from a protective measure. For ECB, five moths caught in a week during silking is a threshold to spray. When these pests are present, they burrow through the corn



A Heliothis trap is mounted on a T-post at the cornfield edge. The lure attracts the moths, and they will be trapped in the upper pouch.



A Heliothis trap, seen at top left, opens at silk height. In foreground, a worker harvests ears into red buckets.

CROP HANDBOOK: CORN

Family: *Poaceae*

husks in the middle of the ear, which ruins the entire ear. Alternatively, instead of monitoring, any corn at V6-V8 growth stage, about four to six weeks after emergence and before reaching 24 inches in height, are sprayed with a pesticide formulation derived from a parasitic fungus called *Beauveria bassiana*. Only one spray of *Beauveria bassiana* per planting is required.

For corn earworm, a different tactic is employed. Corn ears can individually be treated with either a Bt pesticide or Neemix 4.5 pesticide mixture using a Zea-later applicator. The Zea-later dispenses a predetermined amount of product (about one milliliter) using an easy trigger handle. A worker

needs to wear waterproof pants and boots as well as gloves when using the Zea-later. The 32-ounce bottle can be mixed with the pesticide and dilution agents like Golden Pest Spray Oil and water.

To use the Zea-later properly, timing is critical. The Zea-later application should occur two days following full silk emergence, and the silks may be starting to turn brown at this time. However, the silks cannot be fully brown or the application will be too late. If no earworm moths are caught in the traps at this window, the Zea-later application can be skipped. To dispense the pesticide, the nozzle of the handheld Zea-later applicator is pressed into the tip of the corn ear where the silks



Corn silks fully emerged and beginning to brown are ready for Zea-later application.

CROP HANDBOOK: CORN

Family: *Poaceae*



Zea-later application to corn ear tip.

are emerging. The trigger is depressed to dispense the measured amount per ear. Only ears that are full should get the pesticide application. This is usually only one ear per plant, though sometimes two ears on a plant may need to receive the Zea-later application.

Two other pests are sap beetles and Japanese beetles. Both are a nuisance but do not cause significant damage. They will be knocked off during harvest and washing.

In windy conditions, corn is at risk of lodging or falling over. Lodged plants may recover, but some will not produce any harvestable ears.

Sometimes corn smut is observed on ears in the field. Smut is rare and considered a delicacy for some cuisines. These ears are culled from the harvest.



Some lodged plants will not recover.

CROP HANDBOOK: CORN

Family: *Poaceae*

Harvest

Sweet corn is harvested first thing in the morning on the day it is handed out, in order to minimize the conversion of sugars into starches. However, the supersweet sh2 varieties do very well in storage and are slower to convert to starch than other types of sweet corn.

Popcorn is harvested after the stalks have completely dried and turned brittle.

Workers begin harvest on the same side of the field, with each worker responsible for one corn row. Workers carry a

few red buckets to hold harvested corn ears. For quick harvest, each ear is grabbed and twisted firmly while pulling down to dislodge the ear from the stalk. Any extra organic matter from base of the ear is broken off. When buckets are filled, workers carry them straight to the drive row edge of the field to be picked up later. Contents of buckets are dumped into larger harvest bins that have been laid along the outside edge of the field. Workers are advised to wear long sleeves to prevent skin irritation from the stalks.



Corn smut on an ear.

CROP HANDBOOK: CORN

Family: *Poaceae*

Yield

Sweet corn yields are 0.5 to 0.7 ears per row foot. Popcorn yields similarly, at 0.53 ears per row foot.



Harvest bins are lined up down the drive row so harvesters can empty corn into them from their red buckets.



Early-morning sweet corn harvest fills the harvest wagon and is taken back to the packing shed.



Popcorn is harvest ready when the stalks are completely dry and brittle.

CROP HANDBOOK: CORN

Family: *Poaceae*



Corn is one of the more land-intensive crops. Therefore, plantings are limited to one acre in total. Each planting for a share takes half of a one-third-acre field. Sweet corn is usually distributed four to five times per year. The last corn planting is reserved for popcorn. Popcorn is a specialty crop and will usually be distributed once. Occasionally, popcorn stores into May and is included with the first shares of the year. Popcorn is also given out as a bonus item for Thanksgiving boxes.

Optimal number of ears per share is four to six. For popcorn, offering two to four ears at a time is sufficient.

Post-harvest Handling

The primary focus of post-harvest processing for sweet corn is to keep the product cool. In midsummer, corn is dunked in an ice bath in the dunk tank prior to being counted and stored. The purpose of the ice bath is chilling the corn more than washing it, since they are chilled with the husks still covering the ears. The process of dunking also allows for sorting again to check for worm holes on the sides of the ear that indicate European corn borer damage. These ears are not marketable. Some corn earworm damage is tolerated, and CSA members are advised to chop off corn tips if they are worried about finding a worm at the tip of the ear. The ear is still good even when an earworm may have found its way in. When corn is properly treated with Zea-later application, corn earworm control is high.

Corn ears are counted into dark-green bins. Around 75 to 80 ears can fit into one bin.

Popcorn must be cured in a dry, warm environment before being distributed. Ears are placed in a single layer on unused benches in the greenhouse to dry for two weeks. Popcorn will not pop right off the stalk; it will benefit from multiple weeks in storage prior to popping to dry out more. While the cure time of two weeks will help, popcorn will benefit from four weeks or more in storage. This timeframe makes popcorn an ideal crop around Thanksgiving.

The curing and storage environments are monitored for mice, as this pest can easily decimate a popcorn harvest if they find it.

Sweet corn is dunked in an ice bath for hydrocooling.

CROP HANDBOOK: CORN

Family: *Poaceae*

Storage

Sweet corn is stored for a minimal amount of time at 32°F. At UK-CSA, sweet corn is in the cooler for about six hours before being delivered to customers.

Popcorn, once cured, is counted and stored in blue bins when being handed out soon for the CSA. For long-term storage, ears are kept cool at 55°F in lidded, plastic totes. Dried husks are removed for long-term storage.



Bicolor sweet corn, at top left, and yellow sweet corn, top right. Bottom, corn husks are kept on ears at CSA distribution.

CROP HANDBOOK: CUCUMBER

Family: *Cucurbitaceae*

Varieties

Both slicing and pickling cucumber varieties are grown. Both open-pollinated and hybrid cucumber varieties have performed well. Slicing varieties grown include Cobra and Marketmore 76. Pickling varieties grown have included DeliStar, H-19 Little Leaf, and Boothby's Blonde heirloom.

Cucumbers mature in 58 to 63 days from direct seed.

Greenhouse Production

Cucumbers are hand-seeded into 72-cell Winstrip trays. They only require three weeks in the greenhouse, as they are fast growing and will get leggy quickly. However, direct seeding is the preferred production method.

Field Preparations

Cucumbers are fast growing and short-lived due to disease and insect pressures. For successful establishment, they are grown on black plastic mulch beds and row-covered at time

of planting. Plastic beds are cultivated several times prior to planting. Each field holds six or seven beds for summer squash, zucchini, and cucumber combined in one field, spaced at least seven feet or eight feet apart respectively.

Cucumbers require 120 pounds of nitrogen per acre. Granular fertilizer is applied at time of plastic laying.

Direct Seeding

Cucumbers are direct seeded into the plastic mulch. Holes are punched in the plastic with the water wheel setter, with two rows per bed top and 12-inch in-row spacing. Workers place two seeds in each hole and sweep soil on top to finish planting. To keep hands from getting muddy, one hand is kept dry and is only used for seeding, while the other hand does the soil covering.

Earliest planting date is May 5, and latest is July 1. Three plantings of cucumbers are made in succession, spaced about four weeks apart.



Cucumber seeds are placed in a tan tray on the water wheel setter. Workers drop one or two seeds into each dibbled hole by hand and cover with soil.

CROP HANDBOOK: CUCUMBER

Family: *Cucurbitaceae*

Cultural Practices

Cucumber beds are covered with row covers at time of seeding. Row covers should have a small amount of slack to allow for cucumber growth underneath. Row covers are removed once plants are flowering for pollination. Cucumbers are hand-weeded and thinned in the holes at time of uncovering, and then the plastic-covered beds are cultivated before the vines spread past the bed edges.

Cucumbers are attacked by cucumber beetles and squash beetles. Once row covers are removed for pollination, Kaolin clay is sprayed on the leaves to deter insect feeding.

Powdery mildew and downy mildew also occur frequently on cucumbers. Fungicides are rarely applied, since plants are so fast growing and short-lived.

While cucumbers can be trellised for easier harvest, it is not worth the labor investment to install and manage the trellis since cucumbers are so short-lived. In a different growing environment, like a high tunnel, a trellis is beneficial.

Harvest

Cucumbers are harvested three times per week—on Mondays, Wednesdays, and Fridays—on the same schedule as summer squash and zucchini. Fruits are harvested using small harvest knives to cut the fruit at the stem from the plant, or they can be pulled from the stem by hand. Two harvesters walk on either side of each bed. Slicing cucumbers are harvested when seven to 10 inches long, and pickling types are picked when three to five inches long. Cucumbers are ready when filled out



Example of cucumbers grown on a trellis.



Workers harvesting cucumbers search through vines and place cucumbers into red buckets.

CROP HANDBOOK: CUCUMBER

Family: *Cucurbitaceae*

evenly the length of the fruit. Cucumbers that have puckering or tapering at ends are culled. Any oversized cucumbers are also culled. Cucumbers are placed into red buckets or harvest bins, and full buckets are carried to the edge of the field for pick up by the harvest wagon.

Yield

Slicing cucumbers yield 0.5 to 1.0 fruits per row foot; pickling varieties yield 0.45 to 1.0 fruits per row foot.

Cucumbers are included in CSA shares eight to 10 times per year and are a staple crop. Slicing cucumbers are given out

for two-thirds of these distributions, and pickling cucumbers are given out in the last third of the season. CSA members receive two to four slicing cucumbers or four to six pickling cucumbers for each share week.

Post-harvest Handling

Cucumbers are washed in the brush washer. After washing, cucumbers are sorted and counted into light-green bins. Bins are labeled with the number per bin.



Buckets are loaded on the harvest wagon and taken to the packing shed.



Cucumbers are washed on the brush washer and then counted into light-green bins.

CROP HANDBOOK: CUCUMBER

Family: *Cucurbitaceae*

Storage

Cucumbers are optimally stored at 50°F to 55°F. No plastic pallet covers are required over the bins.

Cucumbers can be stored for one to two weeks. Boxes of 20 pounds of cucumbers can be sold for pickling when there is a surplus.



Bulk box of cucumbers, bottom, and four pickling cucumbers for a CSA share distribution, top right.

CROP HANDBOOK: EGGPLANT

Family: *Solanaceae*

Varieties

The standard purple globe varieties grown include Galine and Slim Diamond.

Specialty eggplants include Asian types or Italian types with unique coloring or variegation. Dancer yields similarly to Galine. Nubia is striped pink and white, but yields are significantly less. Slender Asian types like Orient Express, Orient Charm, and Ping Tung Long likewise have reduced production compared to globe eggplant.

Eggplants mature in 65 to 68 days from transplant.

Greenhouse Production

Eggplant starts in 162-cell Winstrip trays with two or three seeds per cell. They are placed on a heat mat at 80°F to 85°F until germination and then removed from the heat mat.

After three weeks, or once seedlings develop true leaves, eggplants are potted up to 50-cell Winstrip trays.

Transplants are ready after seven weeks. They are hardened off gradually during the seventh week. During hardening, flats are covered with row covers on the hardening tables or wagons to prevent flea beetle damage prior to transplanting.

Field Preparations

Eggplant is grown on black plastic mulch or aluminized plastic mulch, with teff or millet living mulch mixed with clover in between the beds.



Globe eggplants are the standard variety grown.

Eggplant requires 120 pounds of nitrogen per acre. Two-thirds of the fertilizer requirements are applied pre-planting, and one-third is delivered via fertigation after eight to 10 weeks of growth.

Transplanting

Eggplant is transplanted in the field using the water wheel setter in two rows per bed at 15- to 18-inch in-row spacing.

Earliest planting date in the field is May 1–10. A second succession can be planted three to four weeks later, around June 5–10. June 15 is the latest recommended planting date.

All eggplant is planted later to reach maturity in August, which is the planned time for eggplant to be included in CSA shares.



Living mulches are seeded in eggplant fields.



Eggplant is transplanted using the water wheel setter.

CROP HANDBOOK: EGGPLANT

Family: *Solanaceae*

Cultural Practices

Eggplant is highly susceptible to flea beetle damage. Plants are netted with 47-gram ProtekNet netting immediately at time of planting. When netting is not used, plants are planted into aluminized plastic mulch.

Once plants begin to flower, netting or covering is removed for pollination. At this growth stage, the eggplant can withstand some flea beetle damage. The row cover is not replaced, as continued pollination is desired for harvesting over multiple weeks.

Common eggplant issues include scarring on the exterior flesh, which may be a result of thrip damage; sunscald; and anthracnose. Excessively scarred fruits are culled. Copper is applied for protection against anthracnose.

Harvest

Eggplants are harvested twice a week, on Monday and Thursday mornings. Eggplants are ready when six to seven inches in length for globe types, and 10 inches for slender Asian varieties. The normal length of pruning shears is eight



Flea beetle damage on leaves, left, can stunt plants when damage is severe on young plants. Netting, right, protects young plants.



Purple eggplant flowers require insect netting or row covers to be removed for pollination.

CROP HANDBOOK: EGGPLANT

Family: *Solanaceae*

inches and serrated harvest knives are seven inches long, so harvesters can compare length of eggplant to their harvest tools for reference.

Eggplants should have a sheen to their skin. Coloring should be deep purple for standard types. Eggplants are firm fruits but have a small amount of give to their skin. When lightly pressed on the outside skin, a small indentation from one's thumb should bounce back. Eggplants should be neither rock-hard nor have a dull appearance. Plants usually yield only one or two mature eggplants at any one time.

Eggplants are removed from the plant by hand with pruners or small serrated knives. Stems are very hard, so tools must be sharp. Eggplants are grabbed from the bottom, as the green calyx around the stem has small spines that will injure hands unless gloves are worn. A small stem of one half-inch to one inch is left on the fruit. Harvested eggplants are placed in red buckets or brown harvest bins. The bins are carried to the outside field edge for pick up.

During harvest, plants are cleaned by clipping off any over-mature, damaged, diseased, or soft fruits and discarding them in the drive rows to be removed from the fields.

Yield

Globe eggplants yield on average 0.15 to 0.5 fruits per row foot per week.

Eggplants are given out in CSA shares six to eight times.

Sometimes eggplant is a choice item, mixed with peppers as part of the member's choice for that week, or alternated weekly with peppers or cucumbers in the share. Ideally, two eggplants are distributed each week they are included in CSA shares.



Buckets of Dancer eggplant, an Italian type.



When harvesting eggplant, workers must look under the plant canopy to find fruits. Use pruners to clip stems.

CROP HANDBOOK: EGGPLANT

Family: *Solanaceae*

Post-harvest Handling

Eggplants are washed using the brush washer. Undersized fruits are sorted out. Many eggplants develop “noses,” but these are still retained for the CSA shares, as fruit quality is unaffected by novel appearances.

After washing, they are counted into light- or dark-green bins, and each bin is labeled with the final count. Bin labels are placed on the short side facing outward when bins are stacked.

Storage

Eggplant should be stored similarly to peppers, at 45°F to 55°F. Plastic pallet covers are placed over stacks of bins. Shelf life is one week.



Washed Ping Tung Long eggplants.



Eggplants are washed on the brush washer, sorted, and counted into green bins.



Noses on eggplants are whimsical and do not affect fruit quality.

CROP HANDBOOK: FENNEL

Family: *Apiaceae*

Varieties

Fennel can be grown as both leaf and bulb types. For bulb fennel, Preludio is used and is available in both raw and pelleted seed. For leaf fennel, Grosfruchtiger is planted and used as an herb. The bulb fennel can also be given out with the fronds, which gives customers two products in one.

Leaf fennel is harvest ready in 50 days, but bulb fennel requires 65 to 70 days to reach mature size from transplanting.

Greenhouse Production

Fennel is seeded into 128-cell Winstrip trays. Greenhouse growth takes seven weeks.

Transplanting

Fennel does best in fall. Fennel is transplanted in July for a September harvest. In-row spacing is nine inches when using the Mechanical Transplanter planter, though fennel can also be grown at six-inch spacing.

Fennel requires 100 pounds of nitrogen per acre. All fertilizer required is banded at planting.



Baby fennel bulbs a few weeks after being transplanted.

CROP HANDBOOK: FENNEL

Family: *Apiaceae*



Fennel bulb harvest.

Cultural Practices

Excessive moisture can cause rot on the base of bulbs. Delayed harvest can also be detrimental to the crop, as quality decreases. Crops are monitored for rot, and bulbs may be harvested early or slightly small to prevent further damage.

Harvest

Fennel leaf is harvested like a bunched herb. A small knife is used to cut fronds above the lower growth point. Leaves are banded together with a small rubber band. Ends are trimmed even with a small knife. See the [Herbs](#) section for more information.

Bulb fennel is cut first with a lettuce field knife or pruners at the base to separate the bulb from the thicker root. Cuts are made below the outermost layer. If there are any soft or browning spots on the outer layers, these outermost layers are peeled off. If the browning is deeper than one layer, it is not worth it to continue peeling off layers. The bulbs with fronds attached are attractive but take up more storage space. For bulb only, clip the fronds one half-inch above the bulb top with a small knife.



To harvest a bulb, the bulb is pushed away to expose the root for clipping.

CROP HANDBOOK: FENNEL

Family: *Apiaceae*



Yield

Fennel bulb yields 0.75–1.0 bulbs per row foot of plants.

Fennel is a specialty crop that is not grown every year. Fennel is included in shares one or two times a year but is usually a choice item with other items as alternates. Members receive one to two bulbs at a time.

Post-harvest Handling

Leaf fennel does not need washing.

Fennel with fronds attached are washed using the rinse conveyor or by doing a quick spray on the bunched washing station. Bulbs only can be washed in the brush washer or rinse conveyor.

Bulbs are counted individually and stored in light-green bins. Fennel with fronds still attached are counted and stacked in alternating directions into light-green, dark-green, or green 1.75-bushel bins.

Fennel bulbs with trimmed roots are piled and ready for loading into bins.



Fennel is the peacock of the vegetable world; its fronds are showy and take up a lot more space than the bulb itself.

CROP HANDBOOK: FENNEL

Family: *Apiaceae*

Storage

Leaf fennel is stored like most herbs, upright in a jar with one inch of water covering the bottom stems. It can be held in the cooler at 32°F.

Fennel bulbs and fronds should be kept at 32°F. Plastic pallet covers are placed over the bins for maximum moisture retention. Any fennel with fronds attached that is not given out or used promptly has the fronds clipped the next day, and the bulb will hold in storage for two to three weeks for a later distribution.



Fennel bulb with fronds.

CROP HANDBOOK: CUT FLOWERS

Family: Various

Varieties

Annual flowers chosen for cut-flower production at the CSA you-pick focus on those that are easy to grow, with prolific and long-lasting blooms.

Favorite cut-flower types include the following: ageratum (Tall Blue Planet); bachelor's buttons (Florist Blue Boy); calendula (Alpha and Zeolights); celosia (Pampas Plume, Chief Mix, and Eternity Improved); cosmos (Double Click Mix); gomphrena, also known as globe amaranth (Strawberry Fields); sunflowers (Jade, Teddy Bear, Starburst series, ProCut series, and Sunrich series); helipterum, also known as everlasting daisy (Pierrot White); marigold (Giant Orange and Gi-

ant Yellow); scabiosa, also known as pincushion flower (Black Knight, Sternkugel); statice (Seeker Mix); strawflowers (Monstrosum Tall Mix, Apricot/Peach Mix); tithonia, also known as Mexican sunflower (Torch); verbena (*Verbena bonariensis*); and zinnia (Benary's Giant Mix, Zinderella Peach).

Other varieties occasionally grown include amaranth, Queen Anne's lace, false Queen Anne's lace, asters, honeywort, drumstick flower, Chinese forget-me-not, dahlia, eucalyptus, matricaria, flowering tobacco, nigella, ornamental grass, phlox, poppies, and snapdragons. While some flowers are perennials or tender perennials in Zone 6b, all the cut flowers are managed as annuals.



You-pick is one of the perks of CSA membership. Flowers are the most popular you-pick item.

CROP HANDBOOK: CUT FLOWERS

Family: Various



Planting crops by height prevents shading any of them out.



Seeds are started in individual flats for germination and covered with vermiculite.

Peredovik sunflowers are grown in the field to border the edges of sweet corn fields. These sunflowers attract beneficial insects and are also harvested once for inclusion into CSA shares.

Varieties are chosen with a range of maturity dates to provide a large harvest window. Earliest maturing flowers, like calendula and some sunflowers, are ready in 50 days, while others may take 100 days or more. Peredovik sunflowers mature closer to 100 days.

Greenhouse Production

While some flowers do best when direct seeded, all flowers for you-pick are transplanted.

Flowers that are in the greenhouse for more than six weeks are seeded into six-inch-by-four-inch L-Series Landmark plastic flats. Unless otherwise indicated, all flats are covered with vermiculite in a thin layer and placed on the mist bench in the greenhouse. Quickly growing flowers, like cosmos and sunflowers, are seeded directly into 72-cell Winstrip trays and do not require misting. Flowers that require germination temperatures above 75°F are placed on a heating mat.

CROP HANDBOOK: CUT FLOWERS

Family: Various



Greenhouse instructions for the standard cut-flower varieties are given in Table 1.

Once flowers germinate, they are removed from the misting bench to prevent waterlogging. When the seedlings have the first set of true leaves, flowers are potted up to 128-cell Winstrip trays. After three weeks of growth in the 128-cell trays, any flowers that outgrow the 128-cell trays and require a larger cell can be potted up a second time into 72-cell Winstrip trays.

Field Preparations

Annual flowers are planted into black plastic-mulched beds.

Flowers may have small differences in nitrogen requirements, but since the flowers are all mixed in the same field, a standard nitrogen requirement rate of 100 pounds per acre is used to calculate fertilizer applications for all cut flowers. Fertilizer is applied pre-planting at time of plastic mulch installation. No fertilizer is applied for Peredovik sunflowers in the field.

Flats are placed under misters in the greenhouse until they fully germinate.

Table 1. Cut-Flower Greenhouse Production Notes

<i>Flower</i>	<i>Days to Germination</i>	<i>Germination Temperature</i>	<i>Seeding Instructions</i>	<i>Transplant Age (Weeks)</i>
Ageratum	7-10	75°F-80°F	Do not cover with media, light vermiculite only	8
Bachelor's Button	7-14	60°F-65°F	1/4" deep, cover lightly	6
Calendula	6-14	70°F	Darkness required, cover completely	8
Celosia	8-14	70°F-80°F	Do not cover with media, light vermiculite only	8
Cosmos	7-10	68°F-72°F	Barely cover, keep moist	5
Gomphrena	5-14	70°F-78°F	Cover lightly, keep moist	8
Helipterum	14-21	65°F-70°F	Cover lightly, keep moist	8
Marigold	4-7	75°F-80°F	Cover lightly	5
Scabiosa	10-12	65°F-70°F	Barely cover with vermiculite	8
Statice	5-14	70°F	Barely cover with vermiculite, light required	8
Strawflower	7-10	70°F-75°F	Do not cover with media, light vermiculite only	8
Sunflower	7-14	70°F-75°F	Cover completely	4
Tithonia	7-14	70°F-85°F	Barely cover	6
Verbena	14-28	60°F-86°F	Stay on dry side	12
Zinnia	3-5	80°F-85°F	Cover, keep moist	5

CROP HANDBOOK: CUT FLOWERS

Family: Various

Transplanting

Cut flowers are transplanted at 12-inch in-row spacing, in two rows per bed. They are transplanted after the danger of frost, in early May.

Flowers are transplanted in ascending order of height to reduce plant shading or overcrowding from larger growing varieties.

Cultural Practices

In general, cut flowers do not have many pests or diseases issues. Cut flowers are a great benefit to the farming system as they attract a wide range of beneficial insects and pollinators. Some cut flowers, like zinnias and dahlias, are susceptible to powdery mildew. They are mowed or removed when production declines.

Sunflowers, due to their height, are staked if needed. Tobacco stakes are placed every 10 to 20 feet on either side of the bed. Twine is wound around the outside of the stakes to hold the stems upright.

Cut flowers are planted in a field specially designated for you-pick for CSA members. This field receives a high volume of foot traffic. A sturdy living mulch, like millet and clover, is established in the aisles between the plastic beds shortly after planting. The living mulch is managed weekly with mowing by a BCS walk behind tractor and flail mower.

When sunflowers have finished sending up new flower heads, the stalks are removed, as they will begin to fall over. A second succession of sunflowers is direct seeded into the cleared holes in the plastic beds.



Sunflowers are staked as a group with twine to hold them inside the bed perimeter.



A living mulch is established between flower beds soon after transplanting.

CROP HANDBOOK: CUT FLOWERS

Family: Various



Sunflowers broadcast on a field edge allow for a one-time harvest for 250 CSA members.

Harvest

You-pick flowers are harvested by CSA members using hand tools. Pruners and small serrated knives work the best. Stems are cut individually close to their base or branching point. Cut stems are best placed at time of harvest into a bucket with one inch of water to keep them fresh.

Sunflowers harvested for the CSA shares are cut using pruners or loppers. Stems two feet in length are kept attached. Extra leaves are removed from the stems. Stems are placed in five-gallon buckets with a few inches of water at the base. Larger plastic totes and bins may also be used to hold sunflowers.

Yield

Since cut flowers are only for on-farm you-pick, yield is not tracked. Poorly performing varieties are noted and not seeded in following years, as the priority is harvest abundance and long harvest length.

For CSA sunflower harvest, members receive at least two stems in their share.

Post-harvest Handling

Flowers are not washed. They are held in moist paper towels or in a jar or bucket with one inch of water to keep them fresh. Ends can be trimmed again at a 45-degree angle before they are placed in their final home or vase.



Harvested sunflowers are kept in buckets or totes with some water to keep them fresh.

CROP HANDBOOK: CUT FLOWERS

Family: Various

Storage

Flowers are not stored in coolers, as they are taken home or distributed immediately after harvest.



Clockwise from top left: A honeybee feeds on verbena; Zeolights calendula; A bumblebee on Chinese forget-me-not; Dara daucus.

CROP HANDBOOK: CUT FLOWERS

Family: Various



Clockwise from top left: Black Knight scabiosa; a butterfly on tithonia; Florist Blue Boy bachelor's buttons; snapdragons.

CROP HANDBOOK: CUT FLOWERS

Family: Various



Clockwise from top left: celosia; ageratum; Sternkugel scabiosa; Strawberry Lemonade sunflower.

CROP HANDBOOK: GARLIC AND ONION

Family: *Allium*

Varieties

Music porcelain hardneck garlic is the variety grown exclusively. This garlic has high storage potential, performs well in Kentucky, and has fantastic flavor.

Onion variety choice is dictated by latitude and corresponding day length. In central Kentucky, only intermediate day length onions can be grown, and options are limited. Many of the best storage onions are not suitable for Kentucky. Therefore, onion varieties are ones that are good for fresh eating and shorter-term storage. For yellow onions, Expression has performed well, better than Candy. For white onions, Sierra Blanca is reliable. For red onions, Cabernet or Monastrell are grown.

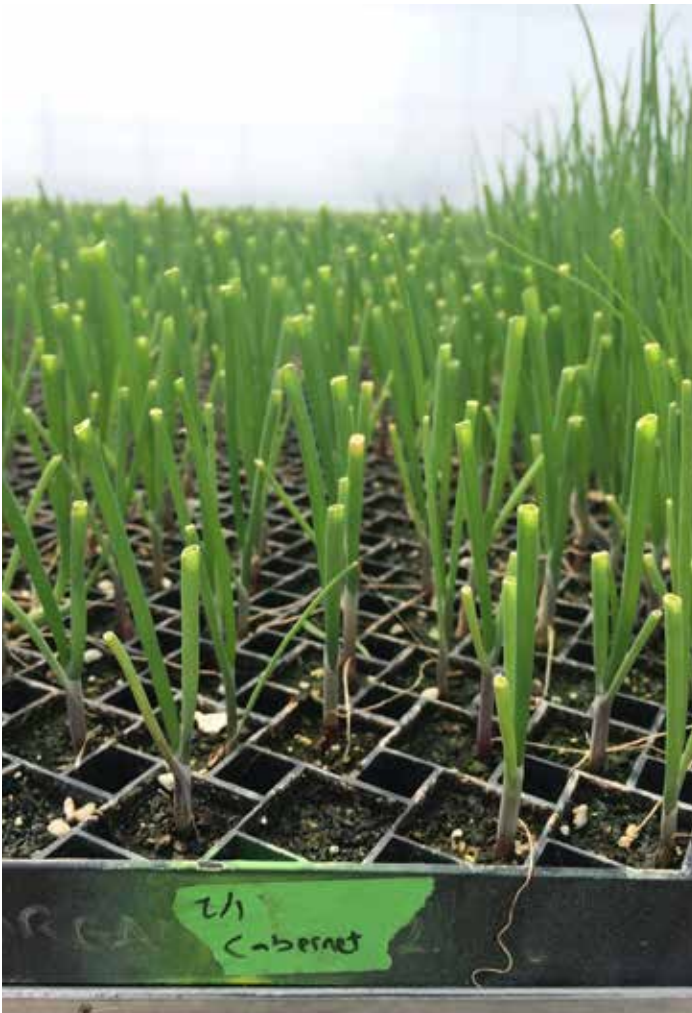
Garlic is one of the few crops that overwinters. This crop is in the ground for nine months, from October to June.

Onions are one of the first transplants of spring in early April and are harvest ready in mid to late July. Onions mature in 100 to 109 days.

Greenhouse Production

Garlic is direct seeded by hand in the beginning or middle of October. Onions will be started in the greenhouse in January in 162-cell Winstrip trays, with one seed per cell. Onion seed with NOP-compliant pellets is preferred. Using pelleted seed is the most reliable way to get even seeding in the greenhouse with only one plant per cell. Onions do not develop strong root systems readily and can be difficult to thin or pot up. Onions will grow for 14 weeks in their greenhouse trays.

After four to five weeks in the greenhouse, plants will be four to six inches tall. They will benefit from a “haircut.” Scissors are used to trim one-third of the green leaves off above the growth point. One-third will be trimmed again four to six weeks later, if needed. These trims help the onion to put energy into its roots for better root ball development. This aids in easier planting. Weekly greenhouse fertigation for onions is recommended after eight weeks in the tray.



Onion transplants on left have been trimmed by a third.



Onion transplants ready to go in the ground.

CROP HANDBOOK: GARLIC AND ONION

Family: *Allium*

Field Preparations

Both garlic and onions are planted on plastic mulch. Plastic mulch-covered beds are installed by late September in anticipation of October planting. Beds for garlic and onions are installed at the same time. Onions are not transplanted until April of the following year, but installing the plastic-covered beds in the prior fall ensures that the crop can be planted in a timely fashion. Spring can be a difficult time to do field work due to soil moisture.

Both fields are planted with a rye-clover living mulch between the beds. This will allow the mulch to establish and overwinter, covering the soil and minimizing erosion. The living mulch may need to be mowed a few times in the spring.

Both garlic and onions require 75 pounds of nitrogen per acre. All fertilizer required is applied pre-planting, at time of plastic laying.

Transplanting

Both onions and garlic are planted on a three-row system on plastic mulch. Garlic is planted at nine-inch spacing in-row, while onion is done at 12-inch spacing. Based on research from Roxbury Farms, garlic performs best when planted on white plastic mulch rather than black; however, black can also be used. Onions are susceptible to thrip damage, therefore they are planted on aluminized plastic mulch. A heat strip in the middle of the plastic may help warm soils for these crops



Garlic is planted on white or black plastic mulch in fall. Crimson clover is sown as a living mulch and will be mowed at bloom in spring.



Onions are planted on aluminized plastic mulch in spring.

CROP HANDBOOK: GARLIC AND ONION

Family: *Allium*



Planting garlic by hand. Each clove is staged in each hole.

in early spring, but they perform equally well on both types of aluminized mulch.

Garlic is best planted in October, around October 5–15, for Kentucky. It can be planted as late as November, but it is better to get it in earlier. When garlic seed is planted by hand, individual cloves are broken apart from bulbs. The cloves themselves do not have to be peeled, so this saves on labor expenditure. The water wheel dibblers or the hand seedbed roller with dibbles are rolled over the bed tops to punch holes at the proper spacing. A five-gallon bucket of loose cloves is carried along the bed as cloves are positioned in the holes for planting, and the planting crew follows behind. This ensures that everyone plants one clove into each hole and no one loses track of where they have already planted.

The flat bottom of the clove is pushed down and the tip or point of the clove is pointing up. The cloves are pushed with thumb and forefinger as far as possible down into the dibbled holes of the plastic mulch bed, and then the surrounding soil is swept with one's finger on top of it. The goal is to have as much soil above the tip of the clove as the clove is high. This translates into approximately one inch of soil above the clove, or workers pushing cloves as far down as the first or second knuckle on the forefinger.

If the soil is very dry, this process will be difficult. Soil moisture under the plastic is checked prior to planting. Irrigation lines can be run under the plastic, or holes can be dibbled in advance and allow rain to filter into the bed prior to planting to make this process easier. Small sections of rebar can also be used to open up holes in the soil for easier hand-planting.

Onions are transplanted using the water wheel setter. Tractor speed for planting three rows of onions is around 0.25 mph.



Garlic is planted on plastic mulch beds, three rows per bed. Living mulches are seeded in between the beds.

CROP HANDBOOK: GARLIC AND ONION

Family: *Allium*

Cultural Practices

Garlic will emerge before going into winter. A few hand-weeding passes of the garlic holes will be beneficial, particularly in spring as plants start to take off. Plants are monitored in May for the emergence of their flower stalks. These stalks will be very curly before eventually straightening and blooming. The stalks, also called garlic scapes, are removed from the plants prior to straightening and blooming. Workers walk the field and snap off each garlic scape at the base where it emerges from the garlic plant, and they place them into a tote or bucket. A lightweight buckets with a slit can be worn on a worker's belt to keep both hands free for quick snapping.

The garlic scapes may need to be harvested more than once if some of the plants are delayed in sending up their scapes. When the scapes begin to straighten, they will stand a foot

above the plant height, so it will be obvious to spot those that may have been missed. Snapping off scapes concentrates the plant's energy in its final month into producing a larger garlic bulb. About one month after garlic scape harvest, check garlic for harvest readiness.

Garlic and onions can both be afflicted with botrytis in spring, which causes neck rot. In organic systems, applying a copper fungicide before major rain events in spring, as temperatures are in the 50°F to 60°F range, will help with prevention. Sprays are usually started in April.

While onions do not produce flower stalks like garlic, they can get overheated or trap too much moisture under the plastic as they begin to bulb out. If using plastic mulch as weed prevention, the plastic mulch is slit open between the rows of plants to bring in more airflow. This is typically done during



Garlic scapes are immature flower stalks. Once these emerge, they are snapped off from the plant.



Garlic scapes can be harvested into buckets. Buckets can be belt-tied for double-handed harvesting.

CROP HANDBOOK: GARLIC AND ONION

Family: *Allium*



During the last month of growth, garlic leaves begin to yellow.

the last month of maturation, if bulbs are beginning to press up underneath the plastic mulch. By dibbling a larger hole in the plastic at planting, this moisture and heat trap may also be avoided.

Harvest

Garlic and onions will give clues for crop readiness based on the decline of their visible leaves. The lower two leaves on garlic will yellow and brown as a first indication. It is helpful to dig up a few garlic bulbs about a month after harvesting garlic scapes to check for clove development and bulb size. There should be fewer than six wrapper layers to be removed before reaching the individual cloves. If there are more than six wrapper layers, the garlic may need more time for development.

Onion necks will begin to weaken as they near full growth. When pressing on the onion neck with two fingers an inch above the bulb, the leaves should readily give and “flop” backward. When around 50 to 75 percent of the necks can easily be pushed over (flopping), they are ready to harvest. At UK-CSA, harvest is begun at 25- to 50-percent neck flop, because it is a challenge to remove so many onions from the field in a timely manner. The onion harvest may take several days, and they cannot be harvested when there is rain or wet conditions. Slightly earlier harvest has also cut down disease incidence and post-harvest rots.



Place fingers an inch above bulb top and push to test for neck weakness.



Neck on onion has “flopped.”

CROP HANDBOOK: GARLIC AND ONION

Family: *Allium*

Since both garlic and onions are grown on plastic mulch, a plastic lifter is used to get under the plants prior to harvest. This will loosen the plants at their roots and unearth the buried plastic edges at once. Plants are pulled out of the plastic and shaken to dislodge soil from the roots. Plants are stacked into piles for field processing. If it is a sunny day, plants can be left in the sun without damage for several hours. Both onions and garlic have their greens clipped prior to storage. Excessive green material prolongs the time needed for curing. About a forefinger's length of stalk, roughly two to three inches, is left above the bulbs as a neck. A pruner or a harvest knife is used

to chop off the leafy material above this length. The roots are trimmed as well.

It is important to inspect the neck of the bulb at the time of harvest. Once the greens are clipped, there should be a solid mass of tissues that are green or white in color. In hardneck garlic, there is a center hard stem, which is not present in onions. If this interior neck is browning or desiccated, these plants are compromised. Compromised bulbs are moved to a cull bin. Knives or pruners used are promptly bleach sanitized so as not to spread any contamination to the next bulb that is processed.



Both onions and garlic are harvested by using a plastic lifter and then pulled into piles.



Trim greens off of garlic bulb at harvest, leaving a few inches of stem.



Left, garlic has neck rot and should be culled or given out fresh. Middle, garlic has mild discoloration at neck tissues. Curing can be attempted, but these are kept separate in the curing environment for evaluation. Right, garlic has a healthy neck and is ready to cure. Be sure to sanitize harvest tools after trimming heads 1 and 2 as a precaution.

CROP HANDBOOK: GARLIC AND ONION

Family: *Allium*



A healthy onion neck.

Post-harvest Handling

Onions are not washed. After clipping greens and roots and shaking off as much soil as possible, they are transferred to the curing location. Garlic can be handled the same way as onions, or it can be washed in the rinse conveyor before being transferred to its curing location. Washed garlic will not require additional peeling prior to being market ready.

Both garlic and onions require one to three weeks of curing time, unless they are being distributed for fresh eating. Curing optimizes storage life. The ideal curing environment will be warm and dry. Harvested crops are not put in direct sunlight, as this can cause sunscald and compromise storage life. While a warm, dark room would be ideal, a production greenhouse is adapted to serve as a curing environment. To prevent sunscald, a shade cloth is draped over the crops. Crops are laid on benches in a single layer. Additional layers are created by stacking racks on top of concrete blocks. The curing area is condensed into two tiers. The final layer uses concrete blocks to elevate the shade cloth above the crops. Air flow is also critical. A large box fan is positioned at the end of the bench to blow air over the tops of crops. Curing takes one to three weeks. After this time, crops are sorted and counted into bur-lap sacks, wax boxes, or bins for holding.



Garlic that is not rinsed prior to curing, top, will have the outermost layer peeled off. Garlic that is washed in the rinse conveyor before curing, bottom, is already clean. Only roots may be trimmed at this point.

CROP HANDBOOK: GARLIC AND ONION

Family: *Allium*



Curing garlic, top, and onions, bottom, on racks that are stacked using concrete blocks. Onions and garlic are organized on curing benches by variety. All questionable items are kept on a separate bench.

CROP HANDBOOK: GARLIC AND ONION

Family: *Allium*



Curing onions under shade cloth.



Processing garlic by peeling soiled outer layer.

When being sorted, bulbs are inspected and felt for any soft sections, and if any are found, the bulbs are culled. If any visible juicing or foul smell is detected in onions, they are placed directly in the compost barrel.

Garlic can have its outermost soil-laden layer peeled off to reveal a bright white layer underneath. Onions may not need to be peeled, unless there are soft spots that need to be inspected. Onion layers can be peeled back until any damaged layers are removed. Peeled onions should be given out promptly as fresh onions.

Yield

Approximately 25 to 28 percent of the garlic harvest will be retained for next year's planting. The nicest, biggest garlic heads are set aside for this purpose. Garlic bulbs that are destined for seed are never refrigerated, as this can trigger growth prematurely after a false "winter" in cold storage.

Garlic yields 0.9 bulbs per row foot. A total of five beds of garlic are grown for CSA, along with two beds for garlic seed.

Onions produce about 0.45 to 0.55 bulbs per row foot. Yellow onions have the fewest culls.

Fresh garlic or fresh onions are a welcome addition to CSA shares when they first come out of the field in late June or early July. After curing, onions are given out six to seven more times, and garlic seven to eight times. Ideally, these items are in shares every two to three weeks. Weeks they are included in shares are staggered for optimal variety. Each time, two onions or two garlic heads are given out. When scapes are distributed in the early part of the season, members receive one bunch of six to 10 scapes banded together.

CROP HANDBOOK: GARLIC AND ONION

Family: *Allium*



Garlic scapes are weighed and bundled with a rubber band for distribution.

CROP HANDBOOK: GARLIC AND ONION

Family: *Allium*

Storage

In general, both cured onions and cured garlic may be stored at room temperature out of direct sunlight, however storage at 32°F will be beneficial to longer shelf life. Garlic that will be saved for seed should never be refrigerated and is kept at ambient temperature in the packing shed. Boxes, bins, or burlap sacks can be used for storage. Some air flow is beneficial. Garlic and onions that are fresh (not cured) are given out promptly and used within two weeks. They are best stored under refrigeration at 32°F until distribution.

Preservation

Garlic and onions can both be dried and ground as a powder. Garlic drying is hastened by slicing peeled cloves into halves or thirds before spreading in a single layer in the dehydrator. Garlic powder is given out in increments of 1.0 to 1.5 ounces, weighed into poly reclosable zipper bags.



The dried cloves are ground into powder and bagged.



Garlic cloves are cut in thirds before loading in the dehydrator.



Garlic scapes are bunched, banded, and piled into a bin for the CSA.

CROP HANDBOOK: GARLIC AND ONION

Family: *Allium*



Two cured garlic heads, trimmed and peeled for CSA shares.



Yellow onions, cured and ready for distribution.

CROP HANDBOOK: GINGER AND TURMERIC

Family: *Zingiberaceae*



Varieties

Bubba Blue and Peruvian Yellow ginger varieties have been grown. For turmeric, Hawaiian Red and Indira Yellow have been grown.

Bubba Blue ginger is high-yielding and low in fiber. Seed pieces are ordered in November. Only tissue-cultured seed is ordered to minimize risk of disease transmission. One pound of ginger or turmeric seed will provide around 10 to 15 seed pieces.

Mature ginger and turmeric are ready after 10 months. Baby ginger and baby turmeric are ready in 120 to 180 days. In zones 6a to 6b, most ginger and turmeric only reach the baby stage.

Greenhouse Production

Ginger and turmeric are pre-sprouted in a greenhouse starting in early February in order to be ready to transplant by the beginning of May.

Ginger and turmeric are rhizomes. The entire rhizome is termed a “hand.” The “fingers” of the hand are separated by snapping or cutting with a knife. Pieces are placed atop two inches of evenly moistened potting mix in a shallow tray or bin. Seed pieces should not be touching. Each finger, or seed piece, is buried under one to two inches of media. The bins are placed on heat mats set at 72°F to 85°F and kept evenly moist. Overwatering can cause rot.

Signs of initiation occur when nodes begin to swell and push out. Initiation may take four to eight weeks. Shoot emergence above the media in the trays should occur within six to 10 weeks. Once shoots have emerged one to two inches above the media, this is the early growth stage. At this stage or later, they can be transplanted.



Seed pieces laid out for pre-sprouting, turmeric on top and ginger on bottom.

Initiation with node swelling.

CROP HANDBOOK: GINGER AND TURMERIC

Family: *Zingiberaceae*

Transplanting

Ginger and turmeric pieces are transplanted once soil temperatures are at 55°F or above. Shoots and initial roots are kept intact as much as possible. Hilling is required for ginger, since the rhizomes grow upwards. The planting area is started by digging a trench six to eight inches deep. Compost and fertilizer are incorporated at the bottom of the trench.

Turmeric does not require hilling and can be planted at a four-inch depth.

Both crops are planted in single rows that are 42 inches apart, if possible. Ample space is given for hilling the ginger. In-row spacing of seed pieces is five to six inches.

Ginger and turmeric are heavy feeders and are fertilized at rates similar to those used for tomatoes. Compost is applied at 15 to 20 tons per acre. Fertilizer is added at planting in the trench. Total plant nitrogen requirements are 150 pounds per acre, but only two-thirds of the nitrogen requirements are applied at planting in the trench. The remaining fertilizer is split into two sidedressed applications to coincide with hilling.

High tunnels are recommended for growing both turmeric and ginger, as these crops benefit from added heat, humidity, and extended length of the growing season to reach maximum potential yield.



Seed piece ready to plant.



Turmeric shoots in the greenhouse, ready to plant.



The solar greenhouse is filled with turmeric and ginger. Each bed has two lines of drip tape.

CROP HANDBOOK: GINGER AND TURMERIC

Family: *Zingiberaceae*

Cultural Practices

Ginger is hilled twice during the growing season. The first hilling happens once the base of the shoot turns from white to pink. The second hilling occurs four to six weeks following. At each hilling, four to six inches of growing media is brought on top of the plants. An additional 25 pounds of nitrogen per acre is also applied at each hilling event, for a total of 50 pounds of nitrogen per acre. Turmeric, while not hilled, also receives the additional fertilizer at the same time as ginger. For turmeric, the added fertilizer is incorporated in the top two inches of soil with a scuffle hoe.

Ginger and turmeric need two lines of drip tape on top of each bed, placed on either side of the row. These lines are removed for ease during hilling and then replaced. Consistent watering is critical, but soil is allowed to mostly dry between irrigation events. Watering every other day may be necessary when grown in high tunnels and the solar greenhouse.

When cultivating weeds in ginger, hoes and hand tools should be used shallowly to avoid damage to the shoots that may be pushing up from underneath.

Ginger and turmeric have few pest problems. Possible insect pests may include wireworms, cutworms, and lepidopterans, but these have not occurred at UK-CSA.



Digging below soil surface reveals the pink zone, which indicates it is time to hill.



Maintenance with weeding, hilling, and irrigating via drip lines.



Washing baby ginger reveals the pink zone vividly.

CROP HANDBOOK: GINGER AND TURMERIC

Family: *Zingiberaceae*

Harvest

Harvest of baby ginger begins four to six months after planting, usually in early October. Baby ginger will have a more fragile epidermis. Plants are gently lifted with digging forks. Six to eight inches of greens are left on the plant if desired, or greens are clipped to within an inch or two above the rhizome, in the pink zone.

Turmeric takes slightly longer to bulk up. Harvest usually begins in late October and may continue into December.

Leaves on plants will begin to brown as the season progresses and the temperatures dip below 40°F. As long as one inch of green shoot is above the rhizome, plants can remain in the ground. Once a killing freeze occurs, plants will quickly brown and wilt. At this point, the crop is harvested quickly.



The lifted turmeric plants have greens clipped.



These turmeric plants are browning from the cold and will be harvested quickly.

CROP HANDBOOK: GINGER AND TURMERIC

Family: *Zingiberaceae*

Yield

Ginger has a large expansion ratio. For every one pound of seed planted, an average of 5.6 to 6.5 pounds of baby ginger is harvested. Some growers can receive 10 or 12 pounds back for every pound planted.

Turmeric is not as vigorous and will take longer to put on weight.

Ginger and turmeric are both specialty CSA crops. CSA shares will occasionally receive dried ginger or turmeric pow-

der in their first shares of the year, and fresh ginger root in their last shares, when ready. Sometimes ginger and turmeric are only made available for purchase around Thanksgiving. CSA members usually receive 1.0 to 1.5 ounces of ginger or turmeric powder at a time, bagged in 4-mil, four-inch-by-four-inch, reclosable-zipper poly bags, or 0.25 to 0.5 pounds of fresh ginger or fresh turmeric roots, either bagged in plastic or held in a quart-sized, green, molded pulp fiber produce basket.



Expansion ratio of ginger can be as much as 1:12.

CROP HANDBOOK: GINGER AND TURMERIC

Family: *Zingiberaceae*

Post-harvest Handling

The ginger and turmeric roots are washed by spraying them off with a hose, because dirt gets into the many crevices. Soaking the roots in the bubbling dunk tank inside a harvest bin also aids in getting the dirt out of crevices, but it is followed by a quick hose spray as a final washing step.



Turmeric is soaked in the dunk tank bubbler and sprayed off to remove soil.



After washing, large turmeric roots will be divided and have roots trimmed.

CROP HANDBOOK: GINGER AND TURMERIC

Family: *Zingiberaceae*

A last trimming with a serrated knife or hand pruners removes any roots and trims leaf stubs, if needed.



Fresh baby ginger after washing and trimming.



Baby ginger and turmeric will be weighed into 0.25- to 0.5-pound increments and packed in plastic bags or produce baskets.

CROP HANDBOOK: GINGER AND TURMERIC

Family: *Zingiberaceae*



Fresh baby turmeric, weighed into a produce basket.

Storage

Turmeric and ginger are kept at 32°F until delivery. Baby ginger and turmeric will only last two to three days in the cooler at peak freshness.

Preservation

Ginger and turmeric can be preserved by freezing in plastic bags. In the freezer, the roots can last for many months. Portions of the ginger or turmeric roots are grated off for use, and any unused portion is returned to the freezer. Thawing the roots results in a loss of texture and is not recommended once frozen.

Both ginger and turmeric can be dehydrated and ground for powder. When dehydrating turmeric, the roots must be peeled and boiled for one hour prior to dehydration to soften the root. Roots of both are sliced thinly before loading into the dehydrator, and they are ground into powder once dehydration is complete.



Ground ginger powder and ground turmeric powder are distributed in poly reclosable bags.

CROP HANDBOOK: GREEN ONIONS

Family: *Allium*

Varieties

The preferred green onion variety grown is Parade. For late plantings or overwintering, Evergreen Hardy White bunching onions are grown.

Plants mature in 60 to 65 days from transplant.

Greenhouse Production

Green onions are started in 128-cell Winstrip trays in the greenhouse in February or March for spring harvest, in May for late summer harvest, and in August for overwintering. Unlike bulb onions, green onions are vacuum seeded, with five to eight seeds per cell. The seeds will clump on the vacuum seeder, which approximates the multiple seeds per cell. Alternatively, the vacuum seeder can drop seeds over a single tray several times in succession to get multiple seeds in each cell.

Green onions do not develop strong root systems readily and are not potted up. Green onions will grow for 10 weeks in their greenhouse trays. They will benefit from greenhouse fertigation weekly after eight weeks of growth.

Field Preparations

Green bunching onions are grown in the bare-ground production system.



Multiple green onion seeds on the vacuum seeder will give clumps of onion plants in each cell.



Seeds still attached to green onion tips in the greenhouse after germination.

CROP HANDBOOK: GREEN ONIONS

Family: *Allium*

Transplanting

Green onions are transplanted on two rows using the Mechanical Transplanter planter and spaced nine inches apart in-row. They are hand-planted on three rows when overwintering in the solar greenhouse or high tunnel.

Earliest planting date in Kentucky is March 25, and latest is July 25 for fall green onions. For overwintering, green onions are planted by November 1.

Green onions require 100 pounds of nitrogen per acre. Fertilizer is applied at planting.

Cultural Practices

Plants are basket weeded and then finger weeded weekly until they are too tall for the tractors to ride over them.

Thrips will sometimes cause feeding damage to the greens themselves, which appears as stippling. Plants are monitored for thrips, but onions can still be given out in CSA shares with minor pest damage.

Harvest

Green onions can be harvested small as scallions, but at UK-CSA they are harvested when fully grown. Fully grown green onions take about two months after transplanting to be ready for harvest, however they are taken before any yellowing of their leaf tips occurs. When the soil is hard, green onions are harvested with the aid of a digging fork to loosen the soil prior to pulling the bunches out of the ground. When the ground is moist, bunches may be readily pulled out by hand without the aid of a digging fork. Workers take care to not snap off the white base of the onion that is held below the soil surface.

Each plant is a clump of five to eight onions. Clumps are separated into individual onions. Yellowed and browned leaves are peeled off in the field. Soil clods are dislodged from the roots. While roots can be trimmed with pruners if time permits, trimming roots is not necessary. Piles of cleaned onions are then assembled into bunches of five to six for larger onions or six to eight for smaller onions. Each bunch is held



Two-row system in the open field.



Three rows of staggered green onions planted in the solar greenhouse.

CROP HANDBOOK: GREEN ONIONS

Family: *Allium*

together with a rubber band. Bands are twisted around the necks of the plants, where the white onions begin to turn green. By laying a harvest tote on its side, the green onions can be packed neatly without bending the tips.



Green onions harvested with the aid of a digging fork.



Cleaned onions are ready for banding.



Onions are cleaned into piles for bunching.



Bunched onions are stacked into bins on their sides for easier packing. Pruners can be used to trim roots in the field.

CROP HANDBOOK: GREEN ONIONS

Family: *Allium*



Bunched green onions with proper rubber band placement.



Green onions that are tall are quickly trimmed with shears in the packing shed.



The outdoor bunched washing station can be used to wash green onions.

Yield

Green onions yield 0.9 to 1.1 bunches per row foot.

In CSA shares, green onions are only given out once in early summer and once in the late summer or early fall.

Post-harvest Handling

Bunches of green onions can either be washed at the bunched washing station or in the rinse conveyor. Since most of the field soil is removed at the harvest stage when peeling back layers, the washing is for hydrocooling and dislodging any remaining soil held in the roots.

If the greens are excessively tall, they may not fit into any of the bins. Tops can be trimmed off with shears to make them easier to pack. Any leaf tips that have begun to yellow can be trimmed or pinched off.

Bunches are packed either into yellow bins, light-green bins, dark-green bins, or green horticulture bins. Green onions are lightweight, and bins can hold many bunches without becoming too heavy.

Storage

Green onions are stored at 32°F. They hold for five to 10 days in the cooler.



Cleaned bunches ready for packing.

CROP HANDBOOK: HERBS, ANNUAL

Family: *Apiaceae* (Cilantro, Dill), *Lamiaceae* (Basil)

Varieties

Cilantro varieties grown are Calypso and Caribe. Dill variety grown is Bouquet.

Basil varieties grown include Prospera and Aroma 2.

Cilantro and dill annual herbs mature in 45 to 50 days from direct seed.

Basil matures in 68 to 74 days from direct seed, or 54 to 64 days from transplant.

Greenhouse Production

While all three herbs can be grown as transplants, cilantro and dill are equally suited for direct seeding and are usually direct seeded in order to have more dense plantings.

Basil is grown in 128-cell Winstrip trays. Plants need six weeks of growth before planting. Minimum air temperatures must be 45°F to begin hardening basil off outside.

Field Preparations

Annual herbs are grown in bare ground.

Direct Seeding

Cilantro and dill are direct seeded using the MaterMacc VegiMacc seeder. Cilantro uses plate 96, 2.5 and is spaced at 1.2 inches, using sprockets 17-18. Dill uses plate 180, 0.8 and is spaced at 0.8 inches, using sprockets 22-17.

Cilantro and dill require 100 pounds of nitrogen per acre, which is all applied at seeding.

Transplanting

Basil is transplanted at nine-inch in-row spacing.

Basil requires 100 pounds of nitrogen per acre, which is all applied at planting.

Cultural Practices

Dill and cilantro will require hand-weeding after planting as they take longer to germinate and weeds will get a head start.

While swallowtail butterfly caterpillars will frequently be spotted among the dill, they seldom cause significant damage and can be tolerated.

When cilantro begins to bolt, it can no longer be harvested. On the other hand, flowers on basil and dill are fine to harvest. Basil flowers can also be pinched off to promote continued leaf production.

Basil is susceptible to damage from Japanese beetles. Right after planting, hoops and coverings are placed over the crops to protect them from pest damage. The earliest planting of basil benefits from added warmth and is row covered. The



Cilantro and dill are hand-weeded after germination.



Swallowtail butterfly caterpillar munching on dill.

CROP HANDBOOK: HERBS, ANNUAL

Family: *Apiaceae* (Cilantro, Dill), *Lamiaceae* (Basil)



Basil is protected from spring cold and Japanese beetles by row cover.

second succession planting of basil is covered with ProtekNet netting as heat benefits are no longer needed.

Harvest

Cilantro and dill can be harvested as soon as it is five to six inches tall. Basil is first harvested after it grows to a larger plant size of at least 12 inches.

Using a small harvest knife, cut cilantro above the growth point close to soil level. Gather several plants into one's hand, or approximately two row feet of plants. Use a small rubber band to band the stems together. Use the harvest knife to trim the cut ends even. Dill is similarly cut and managed, however dill also produces multiple growth points and spreads out. More selective cuts are made throughout the plant as it grows taller to encourage continued growth. Dill flowers are harvested and included in bunches with the leaves.

When basil is cut, pruners or small knives are used. Plants are cut by one-third to one-half, straight across. Bunches are made from one to two plants, stems held together with a thick rubber band.

Cilantro and dill will be ready for a second harvest in two to three weeks, while basil may need three to four weeks of regrowth before harvesting again.

Herbs are harvested on the same day as distribution to maintain their quality.



Cilantro is cut at ground level, above the growth point.



Dill as it grows is more selectively harvested for both leaves and flowers.

CROP HANDBOOK: HERBS, ANNUAL

Family: *Apiaceae* (Cilantro, Dill), *Lamiaceae* (Basil)



Basil is harvested by cutting the plant back by one-third to one-half.



Dill fronds and flowers are bunched for CSA shares.



The diameter of a cilantro bunch is around one and a half to two inches across.

CROP HANDBOOK: HERBS, ANNUAL

Family: *Apiaceae* (Cilantro, Dill), *Lamiaceae* (Basil)

Yield

Basil yields 0.8 bunches per row foot.

Cilantro and dill yield 0.45 bunches per row foot.

Herbs are a specialty item in CSA shares. Each herb will be in CSA shares at least two times during the season; sometimes herb variety is a choice for members. Each member receives one herb bunch per distribution. Basil is paired with tomatoes for shares, and dill is paired with cucumbers, when timing of crop harvests accommodates these pairings.

Post-harvest Handling

Herbs are not washed. They are counted and packed immediately into yellow bins.

Storage

Basil is kept at ambient temperature until distribution, while cilantro and dill are held in cold storage at 32°F.



Example of a good cilantro bunch size for CSA shares.

CROP HANDBOOK: KOHLRABI

Family: *Brassicaceae*

Varieties

There are two types of kohlrabi: smaller headed types and larger storage varieties. Smaller kohlrabies grown include Winner and Kolibri. Kossak is a larger storage type.

Winner and Kolibri mature in 45 days, while Kossak is longer-growing and matures in 80 days from direct seed. From transplant, smaller kohlrabies may be ready in 30 to 40 days.

Greenhouse Production

Kohlrabi is seeded into 128-cell Winstrip trays. They are transplanted at four weeks of age.

Field Preparations

Kohlrabies are transplanted into the bare-ground production system.

Kohlrabi requires 50 pounds of nitrogen per acre, and all fertilizer is applied at time of transplanting.

Transplanting

Both types of kohlrabi are planted using the Mechanical Transplanter planter. Faster maturing varieties of kohlrabi are planted at nine-inch in-row spacing. These kohlrabies can also be planted at six-inch spacing if hand-planted, but nine inches is the closest in-row spacing allowed on the equipment. Storage varieties grow larger and should be spaced 12 inches apart in-row.

Cultural Practices

Hot-water seed treatment is practiced to reduce *Alternaria* diseases. Kohlrabi, like other brassicas, is susceptible to insect pests, most notably cutworm, flea beetle, and harlequin bug. Since they are fast growing, kohlrabi is not usually covered. If worms are an issue, Bt is sprayed.

Plants are basket weeded and then finger weeded weekly until bulbing and expansion increases.



Transplanting with the Mechanical Transplanter planter.



Small kohlrabi just beginning to bulb. One final finger weeding cultivation pass can be done at this stage.

CROP HANDBOOK: KOHLRABI

Family: *Brassicaceae*



Mature kohlrabies in the field will have most of the leaves clipped off at harvest.

Harvest

Smaller kohlrabies are harvested when the bulbs are evenly filled out at three inches in diameter. Kossak storage type is harvested when the crop diameter is eight to 10 inches.

Kohlrabi has a very thick stem. This stem is best clipped with pruners. Plants are angled away from the ground, and the roots are clipped below the kohlrabi bulb. Alternatively, plants can first be pulled entirely out of the ground and stacked in piles or rows for root clipping. Leaves at the top center of the bulb are left attached, while the larger outer leaves are trimmed flush to the bulb. This is purely decorative. If the kohlrabi is going to be stored, all leaves are removed. Leaves are not pulled off by hand, as tearing the outer skin is likely, which compromises storage life. Pruners or a small knife is used to remove leaves close to the bulb surface.

The weight of kohlrabi will quickly add up in a harvest bin. Harvest bins are only filled two-thirds full, or they will require two workers to carry them to the harvest wagon.



Kohlrabies are hand-pulled and laid on the bed top for root and leaf trimming.



CROP HANDBOOK: KOHLRABI

Family: *Brassicaceae*

Yield

Kohlrabi yields 1.3 heads per row foot for smaller varieties.

Kohlrabi is a specialty crops that is only given out one to two times a year. Storage varieties are not grown every year, as customers prefer smaller kohlrabies. Members receive one storage kohlrabi or two regular kohlrabies.



If greens are left attached, kohlrabi can be washed on the bunched washing station pictured, or the rinse conveyor.

Post-harvest Handling

Kohlrabi with leaves attached is washed on the bunched washing station or sent through the rinse conveyor. Kohlrabi bulbs with all leaves cut off are washed on the brush washer. Count kohlrabies into light-green bins. About 40 to 50 bulbs can be held in a bin at a time. For storage kohlrabi, bulbs can be kept in a macro bin until distribution.



If greens are clipped, bulbs are sent through the brush washer.

CROP HANDBOOK: KOHLRABI

Family: *Brassicaceae*



Bulb kohlrabi with greens removed can store for several weeks.

Storage

Brassicas can all be stored at 32°F.

Bins should be covered with plastic to trap moisture. Most kohlrabi stores for two to three months, and Kossak may store for even longer.



Storage varieties can be kept in a macro bin or smaller bins for even longer.

CROP HANDBOOK: LEAFY GREENS (DIRECT SEEDED)

Family: *Brassicaceae* (Arugula, Kale, Mustard, Mizuna, Tatsoi, Asian Greens); *Asteraceae* (Lettuce); *Amaranthaceae* (Spinach)

Varieties

Direct-seeded greens may include any of the following: lettuce and salad mixes (Allstar Gourmet, Wildfire); arugula (Astro); baby kale (Ironman Kale Mix); mustards (Miz America); mizuna (Mizuna); tatsoi (Tatsoi, Red Cloud); Asian greens (Tokyo Bekana); and spinach (Butterfly, Corvair, Responder, Space).

Arugula, lettuce, and spinach are harvestable in 21 to 28 days. Most Asian greens reach full maturity after 40 to 45 days, all from direct seed.

Field Preparations

These leafy greens are direct seeded on bare ground, in two rows per bed top in the field production system and four to six rows per bed top in the biointensive plots and tunnels. Beds with four rows have two lines of drip tape laid on top of the bed, staggered to supply water to two rows each. With five to six rows, three lines of drip tape are used. Drip tape is secured with sod staples every 15 to 20 feet to keep the drip lines in place.



Two-row field of lettuce mix.



Six rows of spinach.



Four types of braising greens, planted one type per row in the tunnels.

CROP HANDBOOK: LEAFY GREENS (DIRECT SEEDED)

Family: *Brassicaceae* (Arugula, Kale, Mustard, Mizuna, Tatsoi, Asian Greens); *Asteraceae* (Lettuce); *Amaranthaceae* (Spinach)

Direct Seeding

Greens are seeded using the MaterMacc VegiMacc vacuum seeder. Greens are not singulated when seeded. Arugula, braising greens, and lettuce mix use seed plate 180, 0.8 with 0.6-inch spacing on sprockets 22-17. Spinach seeds vary in diameter, but they are much larger than lettuce and arugula. Spinach uses seed plate 144, 2.5 and is seeded at 1.2-inch spacing on sprockets 17-20.

In tunnels and biointensive seedings, the single Jang JP-1 push seeder or the Jang JP-6 six-row push seeder are used, with one or up to six hoppers respectively. Jang seed roller selection depends on crop variety and desired density. A full list of Jang settings by crop variety can be found at the [grower's library of Johnny's Selected Seeds](#). The commonly used Jang seed rollers by crop are:

- YYJ-24 for arugula, mizuna, and tatsoi, at 0.5-inch spacing and four to six rows per bed
- MJ-24 for spinach, at 0.5-inch spacing and four rows per bed



Single-row Jang Precision Seeder can make several passes for multiple rows.

- F-24 for lettuce mix, at 0.5-inch spacing (or MJ-24 for denser seeding) at four to six rows per bed

Four varieties of braising greens are grown in one bed. These greens usually include mizuna, tatsoi, and two others, like red tatsoi, arugula, Tokyo Bekana variety, or Miz America variety. In the field, crops are blocked in quarter-bed sections for ease in management. However, in biointensive areas, crops are seeded side by side, with each variety in its own row. This eliminates the need to switch out seed in the hoppers of the Jang seeder.

Greens need 125 pounds of nitrogen per acre, which is all applied prior to seeding in biointensive areas or at seeding in the field.

Cultural Practices

Greens in the brassica family (arugula, mustard, mizuna, tatsoi, and Asian greens) are susceptible to flea beetle damage and are netted at the time of seeding. Hoops are placed over beds to keep 47-gram ProtekNet netting from touching



The ganged Jang JP-6 push seeder unit is heavier to maneuver, but the number of rows and spacing is customizable.

CROP HANDBOOK: LEAFY GREENS (DIRECT SEEDED)

Family: *Brassicaceae* (Arugula, Kale, Mustard, Mizuna, Tatsoi, Asian Greens); *Asteraceae* (Lettuce); *Amaranthaceae* (Spinach)

greens, which would allow insects to feed through the net on the leaves.

Crops are monitored for aphids as well, particularly on lettuce when soil nitrogen is high. Crops grown in high tunnels are more susceptible to aphid outbreaks as temperatures warm. Ladybugs can be ordered and released in tunnels at dusk by misting plants and shaking ladybugs around plant base.

Greens are hand-weeded as needed. In the field with two rows, the basket weeder is used after germination to shallowly cultivate. Finger weeders are aggressive and can rip plants out, so the fingers are adjusted to wider spacing prior to cultivation.

Immediately after first harvest, the basket weeder is used to cultivate the bed tops to help prepare for a clean second harvest. In biointensive plantings, the tine rake is used to cultivate the bed tops after harvest. The rake also does a decent job of pulling out leaves left behind.



Beneficial insects like ladybugs can be released on greens for biocontrol of aphids.



Netting protects arugula from flea beetles and is pulled off prior to harvest.



Basket weeding after a lettuce mix harvest.

CROP HANDBOOK: LEAFY GREENS (DIRECT SEEDED)

Family: *Brassicaceae* (Arugula, Kale, Mustard, Mizuna, Tatsoi, Asian Greens); *Asteraceae* (Lettuce); *Amaranthaceae* (Spinach)

Harvest

All greens are cut with lettuce field knives or serrated knives. Some greens can also be cut using the Quick Cut Greens Harvester. The plants that do the best with the Quick Cut Greens Harvester include smooth spinach, lettuce mix, arugula, and mizuna. Using the Quick Cut Greens Harvester requires at least two to three fully charged batteries for the drills powering the cutter. In addition, two people should pair up to use the Quick Cut Greens Harvester. The harvesting tool can tire the worker holding it. The harvester's partner can relieve them by taking the full load and dumping it into a harvest bin. In addition, the pair can switch jobs to give each a break.



The spinach growth point can be spotted where baby leaves are emerging. Harvest cuts are made above this point.



Proper knife position is critical when harvesting. Hold greens in one hand while cutting with the other.



Harvesting with the Quick Cut Greens Harvester, top, and switching off, bottom.

CROP HANDBOOK: LEAFY GREENS (DIRECT SEEDED)

Family: *Brassicaceae* (Arugula, Kale, Mustard, Mizuna, Tatsoi, Asian Greens); *Asteraceae* (Lettuce); *Amaranthaceae* (Spinach)

Loose greens are harvested past baby crop stage to maximize yield but must be harvested before leaves get too large and bitter tasting. Lettuces should fill out the row and stand five inches tall or more before harvesting. Mizuna may reach seven to eight inches before harvest as one of the fastest-growing greens. Spinach leaf size should be smaller than one's palm. Arugula at three to four inches makes a nice baby leaf, but usually reaches six to seven inches tall prior to harvest.

To harvest efficiently, both hands are used. While one hand holds the knife, the other grabs a large handful of leaves between thumb and fingers. Position preferred cutting implement just above the growth point before cutting evenly parallel to the ground. For successive harvest, the cuts should be made slightly higher than the one previous. Most lettuce mixes in May and June will only yield two harvests before quality declines.



Harvesting braising greens in the field. Squatting in the field saves workers' backs.



A harvester checks size of bunched arugula before banding.

After cutting, the leaves are held in hand loosely to avoid crushing leaf tissues. The bundle is inspected for yellowed leaves, rotten leaves, or weeds. All of these are removed while holding them in hand. Once the handful is clean, leaves are dropped into a clean harvest bin nested into a drag bin. One row is cut at a time on double-row beds, with harvesters starting at either end of the field and working toward the others to meet in the middle. Once a bin is full, having been lightly pushed down from above to fill the bin well, the nested harvest bin is pulled out of the drag bin and brought to the harvest wagon in the drive row. Bins are placed in the shade beneath the wagon. Keeping greens out of direct sunlight and bringing them to the pack shed quickly after harvest are key to high green quality.

A harvest bin holds six to 10 pounds of greens, depending on variety and pack density. For the CSA, members ideally receive a half-pound of greens per distribution. For braising or cooking greens, the ideal quantity is 0.75 pounds, since they will cook down.

Spinach and arugula are also occasionally bunched at harvest rather than harvested loose. Spinach is cut into bunches, having the plant cut below the growth point in the root zone. The bunching method removes the entire plant and removes the chance for second harvest. Several plants are gathered in hand and aligned, and then they are banded with a twist tie or rubber band at the highest possible point on the stem, closest to the leaf base. Arugula can still be cut as loose greens, but greens are gathered in hand and tied with a rubber band around the base. The amount of greens should be about two inches in diameter when held tightly at the stem base.

Yield

Green yield varies by planting location and field conditions, as well as time of year.

Arugula averages 0.21 pounds per row foot. Lettuce mix averages 0.39 pounds per row foot. Spinach averages 0.26 pounds per row foot. Braising greens (mizuna, tatsoi, Asian greens, mustards) average 0.40 pounds per row foot.

All loose greens, particularly lettuce mixes, are a staple crop in the CSA shares. Loose lettuce mixes are alternated with head lettuce for variety. Lettuce mix is in shares four to six times a year, in both early season and late season. Spinach is given out four to six times as well, split between late spring and fall. Arugula is always included at least once in both spring and fall; in spring, arugula bolts quickly, making a second harvest unreliable. Other loose greens, like Asian greens and baby kale, are specialty items and may only be included in shares one to three times a year.

CROP HANDBOOK: LEAFY GREENS (DIRECT SEEDED)

Family: *Brassicaceae* (Arugula, Kale, Mustard, Mizuna, Tatsoi, Asian Greens); *Asteraceae* (Lettuce); *Amaranthaceae* (Spinach)



Greens are washed in the dunk tank with the bubbler.

Post-harvest Handling

Greens are washed in the dunk tank with the bubbler. Approximately four to five full bins can be emptied into the tank at one time for washing and agitation. Workers look for any large weeds or debris to remove by hand. All loose greens are loaded into one of the Electrolux-Dito Electric Vegetable Dryers. These industrial salad spinners have a removable basket to hold greens, which is filled no more than three-quarters full. Each spinner is run for one and a half to two minutes to remove excess water. Spinners are alternated so that a spinner is always working while another is being loaded or unloaded. Spun greens are emptied into clean, dark-green bins, weighed, and taken into the cooler. Any weeds spotted are pulled out as greens are dumped into bins.



Two Electrolux industrial salad spinners work in tandem to remove excess water from leaves.



Spun greens are unloaded into a dark-green bin.

CROP HANDBOOK: LEAFY GREENS (DIRECT SEEDED)

Family: *Brassicaceae* (Arugula, Kale, Mustard, Mizuna, Tatsoi, Asian Greens); *Asteraceae* (Lettuce); *Amaranthaceae* (Spinach)



When bagging, check for and remove weeds.

Once the dunk tank is nearly empty, a mesh skimmer is swept across the water surface to collect final leaves and prepare for the next wash cycle.

Bunched spinach and arugula are washed in the dunk tank with the bubbler and should simply be shaken prior to setting in a dark-green bin.

Dark-green bins hold around 20 pounds of loose greens. Greens are ideally left to drip dry for a few hours or overnight prior to bagging into individual CSA share amounts. Greens are weighed in plastic bags, and any remaining weeds spotted are removed at this stage. Bags are filled to the appropriate weight. The bags can be either twisted to close, releasing a portion of the air prior to the twist, or the tops can be folded over cleanly. Bags are placed in dark-green bins, with the bag openings sitting on top. Bags should not be compressed, as this will damage leaves.

Bins can hold around 15 to 20 bags per bin, split in two layers.



Loose greens are bagged using scales and plastic bags before being packed into dark-green bins.

CROP HANDBOOK: LEAFY GREENS (DIRECT SEEDED)

Family: *Brassicaceae* (Arugula, Kale, Mustard, Mizuna, Tatsoi, Asian Greens); *Asteraceae* (Lettuce); *Amaranthaceae* (Spinach)

Storage

Greens are stored at 32°F. If greens are loose, bins are covered with plastic pallet covers. Greens will last for seven to 14 days. Kale may last longer, up to three weeks.



Bunched arugula and bunched spinach, left and right, are banded with a twist tie or rubber band.



Loose salad greens, left, and loose spinach, right, are packed into plastic bags, and bags are layered into bins, right. Greens are packed with care so as not to crush leaves.

CROP HANDBOOK: LEEKS

Family: *Allium*

Varieties

Leek varieties grown are King Richard, and Bandit for overwintering. Leeks can withstand temperatures down to 20°F, or possibly lower when choosing an overwintering variety; Bandit is more likely to withstand colder temperatures in winter than King Richard.

King Richard is an earlier leek, ready in 75 days from transplant. Bandit takes 120 days.

Greenhouse Production

Leeks are seeded two to three seeds per cell in 128-cell Winstrip trays for germination. After five to six weeks, leeks are potted up to 72-cell Winstrip trays, with one plant per cell. Leeks spend 12 weeks in their greenhouse trays and will benefit from weekly fertigation the last two to three weeks before planting. Seeds are started in the middle of February for an early May planting.



Leeks have distinct V-shaped leaves.

Transplanting

Leeks can be planted three different ways. The key for good leeks is to grow a long, white shank on the plant. The white part of the plant is the part that is most desirable for cooking and eating. These methods of planting will all accomplish this goal, with varying tradeoffs.

1. Transplant into bare ground with Mechanical Transplanter planter or hand-planting, followed by regular hilling. This method is simplest, however there is considerable hand labor with chop hoes to keep weeds controlled and hills maintained. There is also an upper limit of what amount of hilling you can do on top of the plants.
2. Augur six-inch holes in the soil, then hand-drop plants into each hole, scuffing soil into the hole only partway with one's shoe. As plants are cultivated over the course of the season, and more soil will backfill as the plant grows. This is a beautifully efficient way to get long, straight, white shanks. However, there is considerable labor on the front end to accomplish the planting. In addition, it is easy to burn through drill batteries when using the augur.



Planting leeks by auguring holes.

CROP HANDBOOK: LEEKS

Family: *Allium*



Plants are dropped in the hole.



Leek cultivations gradually fill in the soil on top.

3. Plant and cultivate leeks as you would a potato. In the UK-CSA system, two rows of trenches are dug 30 inches apart. Leeks are hand-dropped into the trenches, and all should be angled to lay on the same side of the trench. The potato tool bar with hiller discs is used to bury the bottom part of the leek. Leeks may sit somewhat sideways, which produces some curved shanks. However, leeks can be cultivated by tractor with the Lilliston Rolling Cultivators and hilled in this manner as well.



Planting leeks by dropping plants in trenches and then hilling with Lilliston Rolling Cultivators.

CROP HANDBOOK: LEEKS

Family: *Allium*



Leeks lay on top of the soil after being dug.

The third method has become the standard leek-planting system.

In-row spacing for leeks is five to six inches.

Leeks require 150 pounds of nitrogen per acre. Two-thirds of the fertilizer requirement is sidedressed pre-planting with the Lilliston Rolling Cultivators. The remaining fertility is provided by fertigation after eight to 10 weeks of growth.

Cultural Practices

Leeks are hilled two times with the Lilliston Rolling Cultivators. Workers walk the field to scuffle or chop hoe any weeds not taken out by the cultivator.

Harvest

The leek's readiness is determined by the overall diameter of the shank, which should be around 1.5 inches. The lowest leaves may have begun to yellow. Leeks are harvested by hand with a digging fork. The greens are very long and can be chopped off straight at the top or at an angle on either side to create a fan shape at the top. Roots are trimmed to a quarter-inch or less, using pruning shears or a serrated knife. Leek roots are inspected for entrance holes caused by root maggots, and any that have been affected are culled. Browning of tissues and a sour rot smell is frequently present when root maggots have burrowed into a leek.



A pair of workers trim leek tops with hedge shears into a fan shape, as seen below.



Leeks after trimming tops into fan shape.

CROP HANDBOOK: LEEKS

Family: *Allium*



Washing leeks at an outdoor washing station. The main focus is to loosen soil caked into roots. Roots are trimmed in advance for easier washing.

Post-harvest Handling

Leeks are washed using the bunched washing station or sent through the rinse conveyor. Higher pressure sprays may be needed to dislodge soil from the tight roots. Leeks are counted and stacked lengthwise, facing in the same direction, into light-green or dark-green bins. Total number of leeks per bin is recorded on labeling tape that is placed on the end of the bin, and bins are stacked in the cooler.

Yield

Leeks suffer from root maggots that burrow into the base of the white shank and create an area for rot. Some years have resulted in up to a 33-percent loss. Average yields have ranged from 0.82 leeks per row foot to two leeks per row foot.

For CSA shares, leeks are given out one or two times a year. Each share receives three to four leeks per bunch. Leeks can be bunched with a rubber band or kept loose as individual stalks. Leeks are frequently paired with an early potato for distribution in late July.

Storage

Leeks are kept under refrigeration at 32°F. Bins are covered with plastic pallet covers at the end of the day.



Leeks are given out in the CSA shares in bunches of three to four banded together, or they are loose and selected individually.

CROP HANDBOOK: LETTUCE, HEADS

Family: *Asteraceae*

Varieties

There are several different types of lettuce heads that are included in CSA shares ever year. Butterhead lettuces, grown only in spring, include Mirlo and Nancy. Leaf lettuces include Green Star and Ruby Sky. Batavian lettuce heads grown are Lovelock and Muir. Romaine lettuce heads grown are Coastal Star, Jericho, and Winter Density in the off season. Oakleaf lettuce heads grown are Panisse.

In addition, Salanova lettuces are grown as heads but are harvested as looseleaf lettuces. The Foundation Collection and Premier Collection are grown together.

Head lettuces mature in 50 to 58 days from transplant for full-size heads.

Greenhouse Production

Lettuce seedlings are started in 128-cell Winstrip trays. They are four to five weeks old at time of transplant.

Field Preparations

Head lettuces are grown in the bare-ground production system. They can also be grown biointensively on bare ground or in woven landscape fabric with holes burned in it, with three to four rows per bed.



Lettuce plug pulls readily from tray and is ready to be planted.

Transplanting

Earliest head lettuce planting date is March 25. The latest planting date is August 1. Cold-hardy varieties like Coastal Star and Winter Density can be planted through the middle or end of September.

Lettuces are transplanted with the Mechanical Transplanter planter, or they are hand-planted in biointensive applications. Heads are spaced 12 inches apart in-row. Salanova types are grown six to eight inches apart in-row, with four rows per bed in the biointensive system.

Head lettuces require 125 pounds of nitrogen per acre. All fertilizer required will be applied at planting.



Four rows of Salanova lettuce, planted in a high tunnel.



Three rows of romaine lettuce, planted on black woven landscape fabric.

CROP HANDBOOK: LETTUCE, HEADS

Family: *Asteraceae*



A two-row field of lettuce, with leaf lettuce on left and butterhead on right.

Cultural Practices

Primary pests of lettuce include aphids, grasshoppers, and slugs, particularly in tunnels. Lettuces are cultivated using the finger weeder until the formation of heads, which can be damaged by the cultivator.

Lettuce is prone to bolting as it matures into the heat of summer. Bolting will cause lettuces to look like Christmas trees if allowed to grow. The middle part of the lettuce head begins to elongate and separate from the outer layers of leaves. This also results in lettuce that tastes bitter. To prevent bolting, keeping lettuce cool is critical. Success with late plantings of head lettuce relies on selecting the best types that are heat- and bolt-tolerant; Lovelock is the most reliable variety in heat. In addition, heads can be kept cool through natural shading from a buffer strip of cover crop, like buckwheat, adjacent to the lettuce bed. The cover crop is seeded a few weeks prior to the lettuce being transplanted to get it established and give it a head start on growth.

Harvest

Lettuce head harvest is based on head size as well as balancing the CSA shares. Doubling up lettuce in a given week is avoided. Lettuce heads should be full but without any evidence of bolting. The center of the heads can be felt for a hard stem that begins to form at the initiation of bolting. If the lettuce is not bolting, no hard stem in the center of the head will be felt. Some romaine lettuces will also have their tips curl inward to form an interior head, known as the romaine “heart,” but this does not always develop in every variety. Butterhead types form a rounded center head. Batavian, oakleaf, and leaf lettuces do not form rounded or wrapped centers. These heads stay loose and open in the interior.



Buckwheat planted on the east side of this plot shaded lettuce out and kept heads from bolting prematurely.



A very hot fall resulted in all the romaine lettuces becoming bolted “Christmas trees.”

CROP HANDBOOK: LETTUCE, HEADS

Family: *Asteraceae*



Proper lettuce head harvest relies on knife placement.

Lettuce can be harvested on the day of distribution or a day in advance. Lettuce is always harvested at the coolest part of the day. It may be harvested when wet as well; any moisture will help to keep the lettuce fresh. Harvesters use one hand to hold back the leaves and find the first outer layer of leaves that is not yellow, brown, or damaged. Harvesters use the other hand to position a lettuce field knife at the head's base, cutting just above any yellow leaves. Careful cutting leaves damaged leaves, usually on the outermost layer, in the field and eliminates the time that would be spent pulling damaged leaves off by hand. The cut is made through the lettuce stem, parallel to the ground. The cut should be low enough that the head stays intact as one piece; if the leaves of the head begin to fall apart, the cut was made too high.

The cut end will exude a milky-looking fluid that is made of latex, which is naturally occurring. This latex exudate can smear on lettuce leaves and be mistaken for bird droppings. In order to keep the lettuce leaves clean from any latex, pack all heads upside down with the cut ends facing up. Do not lay head lettuce on top of a cut end.

Depending on head size, eight to 14 heads will fit inside a harvest bin.

Yield

Romaine and butterhead lettuces are the lowest yielding, at only 0.5 to 0.7 heads per row foot. Other lettuce varieties have an average yield of 0.75 heads per row foot.

Lettuce is a staple crop in the CSA shares. Members receive head lettuces three to four times in spring and three to four times in fall. Lettuce heads are alternated with lettuce salad mixes. CSA members will easily get overwhelmed by too much lettuce, therefore only one head of lettuce per week is sufficient for the share amount. If heads have to be harvested small, two heads can be banded together as an equivalent amount.



Cut end shown here has a milky exudate.



Above and below, proper packing of lettuce heads in bins.

CROP HANDBOOK: LETTUCE, HEADS

Family: *Asteraceae*

Post-harvest Handling

Lettuce is washed in the dunk tank with the bubbler. The cut ends with the latex fluid should be rubbed well prior to pulling out of the tank. All heads are shaken firmly upside down to drain water out of the interior of the head. Lettuce heads are packed into dark-green bins with the tips facing down. The heads will continue to drip-dry when situated with the tops facing down. Once the cut ends are washed, lettuce heads can be stacked in two layers.

Damaged leaves on the outer layers can be removed; however, many layers should not be removed or the head will lose its size and structure.

Lettuce heads are tabulated by counts per bin. A standard number of heads are packed in the bins for reliable counts that can be double-checked.

Storage

Lettuce is stored in the cooler at 32°F, and plastic pallet covers are placed over the bins for moisture retention.

Some head lettuces, like romaine, will hold in the cooler for 21 days or more. Most head lettuces are best consumed within seven to 14 days.



Panisse oakleaf lettuce head.



Coastal Star romaine lettuce head. The head does not always curl inward at the center.



Butterhead lettuce head.



Lovelock Batavian lettuce head. This head was harvested in the third week of June, with no bolting. Note feet for size reference.

CROP HANDBOOK: PEPPERS

Family: *Solanaceae*



Examples of red bell pepper, left, and yellow bull's horn sweet pepper, right.

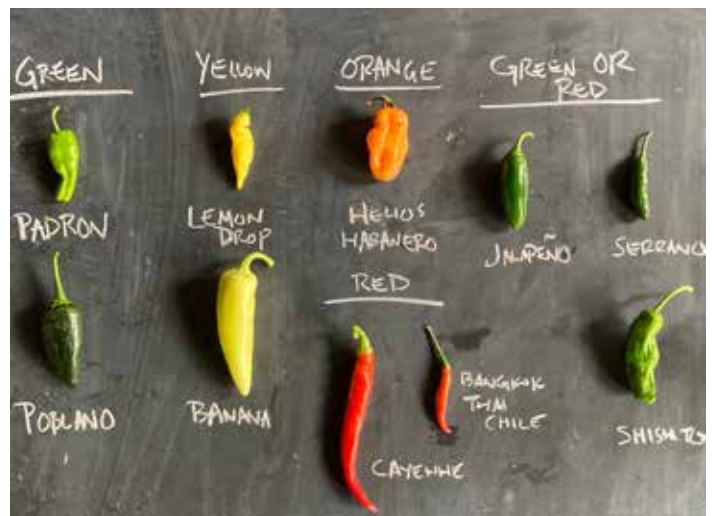
Varieties

Green and red bell peppers grown include Aristotle, La-belle, and Socrates.

Orange and yellow bell peppers grown include Milena (tunnels only), Abay, and Golden California Wonder.

Sweet peppers grown include: Carmen and Escamillo. Both are Italian Corno Di Toro, or "bull's horn" types.

Specialty peppers grown change annually but have included the following: Mellow Star (shishito); Boris or Goddess (banana); Jedi or Jalafuego (jalapeno); Red Ember or Red Flame (cayenne); Bangkok (Thai chili); Baron, Tiburon, or Bastan (poblano); Lemon Drop (Peruvian); Helios (habanero); Numex Suave Orange (mild habanero type); Hot Rod (serrano); Hungarian hot wax; Capperino (cherry); and Padron Spanish heirloom.



Specialty peppers are included in the you-pick field and identified for CSA members.

CROP HANDBOOK: PEPPERS

Family: *Solanaceae*



Peppers are grown on black plastic mulch with teff living mulch.

Greenhouse Production

Peppers start in 162-cell Winstrip trays, with two or three seeds per cell. They are placed on a heat mat at 80°F to 85°F until germination and then removed from the heat mat.

After 10 to 21 days, or once seedlings develop true leaves, peppers are potted up to 50-cell Winstrip trays.

Transplants are ready after eight weeks.

Field Preparations

Peppers are grown on black plastic mulch with teff living mulch in between the beds.

Peppers require 150 pounds of nitrogen per acre. Two-thirds of the required fertilizer is applied at time of plastic laying, and the remaining third of the fertilizer requirement is fertigated after eight to 10 weeks of growth.

Transplanting

Peppers are transplanted in the field using the water wheel transplanter, in two rows per bed at 15-inch in-row spacing.

Peppers are transplanted in high tunnels by hand on black woven landscape fabric. Tunnel peppers are planted in two rows per bed at 15-inch in-row spacing. Holes are pre-burned into landscape fabric at this spacing. Six beds with double rows can fit inside one high tunnel. In the caterpillar tunnel, four single rows can fit inside.

Normal planting date in the tunnel is April 10–15. Normal planting date in the field is May 1–10. Latest planting date recommended is July 1.



Peppers are transplanted in the field with the water wheel transplanter. In tunnels, row covers are used in the early season if temperatures drop. Hoops are needed when plants are young.

CROP HANDBOOK: PEPPERS

Family: *Solanaceae*



Tunnel peppers are staked with wooden posts, rebar, or metal T-posts.



Peppers are strung in the Florida weave pattern near the base and strung a second time for additional support.

Cultural Practices

In the field, peppers are not staked. In the tunnel, staking is required due to plant vigor. Stakes are placed between every two plants, and then plants are tied up using the Florida weave. (For more detail, see the [Tomato Tying](#) section of the SOP manual.) Plants are secured with the first string about four to six inches off the ground. Second and third strings are added at four-inch intervals as plants grow in order to box plants in and keep them from flopping into the walkways.

The king flower, which is the first flower, is removed from tunnel peppers to aid in establishment and sturdier plant structure to support fruit load.

Common pepper diseases include anthracnose, bacterial spot, and bacterial speck, especially in wet seasons. Copper is a protective fungicide that is applied at regular seven- to 14-day intervals, as needed. Sunscald can also ruin many fruits when leaf coverage is inadequate.



Example of sunscald on pepper.

CROP HANDBOOK: PEPPERS

Family: *Solanaceae*

Harvest

Bell peppers are ready when shoulders are risen above the stem base, and two to four lobes are clearly defined on the bottom of the pepper. First peppers are the largest. Only one to four peppers are usually harvested from a plant at any one time. Largest peppers are harvested first and smaller peppers stay on the plant to fully develop. Any green pepper that is in transition to red is left on the plant until color is 80 to 100 percent developed. All Corno Di Toro peppers, yellow bell peppers, and orange bell peppers are harvested at 80 to 100 percent of full color development; they are not harvested when green.

Each worker harvests from one row of peppers, and all workers harvest in the same direction down the length of the field. Peppers are removed from the plant by hand as long as the stem remains intact. Pruners or small serrated knives are also used to cut pepper stems. Each pepper keeps one to two inches of stem. Harvested peppers are placed in red buckets or brown harvest bins. The bins are carried to the outside field edge for pick up with the harvest wagon.

During harvest, plants are cleaned by clipping off any damaged, diseased, or soft fruits, which are discarded in drive rows for removal from the fields. All culled peppers are removed from tunnels and composted.



Red bull's horn peppers harvested using a small serrated knife and loaded into harvest totes.

Full buckets and bins are carried to the field edge for pick up.

CROP HANDBOOK: PEPPERS

Family: *Solanaceae*

Yield

Green and red bell peppers yield on average 0.35 to 0.5 peppers per row foot. Tunnel peppers, which are exclusively yellow and orange bell peppers, have a yield range of 0.15 to 0.55 peppers per row foot. Sweet peppers have an average yield of 0.38 peppers per row foot. The first flush of peppers is always the greatest.

Peppers are a staple crop and given out in CSA shares 10 to 14 times. Specialty peppers like banana and shishito are distributed two to four times, and hot peppers one to two times. Target quantity per share is two to four bell or sweet peppers, four shishito or banana peppers (or mix and match), and four to six hot peppers (mix and match).



Orange and yellow bell peppers are much higher yielding when grown in a high tunnel.

CROP HANDBOOK: PEPPERS

Family: *Solanaceae*

Post-harvest Handling

Larger peppers are washed using the brush washer. Smaller hot peppers, shishito, and banana peppers are not washed, as they will get caught in the machine. After washing, they are counted into light- or dark-green bins, and each bin is labeled

with the final count. When counting and sorting, green bell peppers are counted separately from the red, orange, and yellow bell peppers. Sweet peppers and specialty peppers are also counted separately.



Larger peppers are washed on the brush washer and then sorted.

CROP HANDBOOK: PEPPERS

Family: *Solanaceae*

Any small or damaged fruits, or any with underdeveloped color, are culled. Bin labels are placed on the short side facing outward when bins are stacked.



These peppers do not have 80 to 100 percent developed coloration and should not have been harvested.

CROP HANDBOOK: PEPPERS

Family: *Solanaceae*

Storage

Peppers are stored at 45°F to 55°F. Plastic pallet covers are placed over stacks of bins.



Stakes and T-posts are removed with a T-post remover after the final tunnel pepper harvest.



Mellow Star shishito peppers.

CROP HANDBOOK: POTATOES

Family: *Solanaceae*

Varieties

Potatoes are divided into groups either based on maturity date, by skin and flesh color, or by storage life.

Potatoes that have longer storage and better disease resistance are selected. However, CSA customers love unique potatoes, so potato varieties are diversified beyond the standard buff-skin-with-white-flesh varieties.

Early potatoes (55 to 70 days to maturity) grown with success include Red Gold, Chieftain, and Satina. Red Gold and Chieftain are the primary red-skinned varieties grown.

Mid-season potatoes (70 to 90 days to maturity) include Kennebec, Magic Molly, Nicola, Purple Majesty, Purple Viking, and Salem.

Late-season potatoes (90 to 110 days to maturity) include Elba, German Butterball, and Pontiac.

Magic Molly is the only fingerling grown. It has purple skin and flesh. Purple Viking and Purple Majesty also have specialty coloring.

Chitting

Potatoes benefit from a process of pre-sprouting called chitting to prepare them for planting. Chitting, or green-sprouting, the seed pieces before they go into the soil gives them a head start on the growing season. Whole seed potatoes are set in two to three layers in yellow bins. Bins are stacked in a cool place out of direct sunlight. Bins are labeled with the variety names. The process of chitting takes three to four weeks prior to planting.

Field Preparations

Potatoes are planted on bare ground, in two rows per bed that have been trenched. The trenches help to get the seed pieces planted deeply and allow for hilling on top. The potato tool bar is hooked up to the Kubota 9540 with two Willisie furrowers spaced 30 inches apart. Trenches are dug about four to six inches deep. All trenches are dug in advance of planting to set the bed spacing. The tractor's wheel tracks act as a guide to line up the next beds. A 50-foot-wide field can fit eight potato beds, but they are tight. Wheel tracks must overlap completely. For a seven-bed field, wheel tracks are only overlapped by half to allow a bit more room for hilling and cultivating.



Seed potatoes chitting in bins.



Purple Viking potatoes.



Furrows made in preparation for planting.

CROP HANDBOOK: POTATOES

Family: *Solanaceae*

Planting

Potatoes are cut into pieces prior to planting. The ideal size is two ounces per seed piece. A scale is used to check the cut pieces until workers are adept at cutting the ideal size. Each piece must contain at least one or two potato eyes, which may be sprouting. Cut seed pieces are placed into bins to take to the field. Pieces are handled gently in order to retain the sprouts.

Workers wear apple harvest bags that crisscross across one's back for planting. Each bag is filled with seed pieces. Workers walk along the wheel tracks of each bed and plant

one row at a time. Seed pieces are dropped into the trenches and adjusted with one's foot rather than stooping down to fix by hand. This method is efficient and easier to keep both hands free for planting. While the pieces will grow however they land in the trench, it is best to aim to have sprouts topmost. To achieve this, workers are trained to have a very firm throw of each piece into the trench rather than casually dropping it. Workers aim for eight- to 12-inch spacing of seed pieces in-row. This translates to one to two pieces thrown with every step. Workers can even use the length of their own foot as a guide on piece spacing.



Cutting purple Magic Molly potatoes.



All ages can learn the art of the potato-planting throw.



In-row spacing is gauged by foot length.

CROP HANDBOOK: POTATOES

Family: *Solanaceae*

Once all rows are planted, each bed is covered in succession. The two Willsie furrowers on the potato tool bar are switched out for pairs of hiller discs. The angle and height of the hiller discs are adjusted for optimized covering. The hiller discs lightly cover the pieces as the tractor drives over them. A second pass is sometimes required.

Potatoes are dry-farmed. Drip irrigation lines can be buried into the trenches after the seed pieces are thrown down, but it is challenging to keep them buried when the trenches are filled. A worker will need to follow behind the tractor and make sure the driver stays aligned with the rows, or the irrigation lines may need to be held under tension, so they don't buckle and get out of alignment. This difficulty led to an experiment in dry farming, and no reduction in crop performance was observed.

Planting can be done either early or late. There are advantages and disadvantages to both.

Early-planting challenges include:

- Ability to secure seed potatoes early enough. Some companies will not ship in February or March when risk of freezing is still high.
- Field conditions being dry enough for spading and digging trenches in late March.
- Potential for attack by the Colorado potato beetle (CPB).
- Risk of late freeze.

Early-planting advantages include:

- Getting a head start on potato growth and tuber formation for earlier harvest.
- Avoiding some blight and disease pressures that intensify later in the season by harvesting earlier.

Late-planting challenges include:

- A busier time of year for planting potatoes, coinciding with other plantings.
- More challenging conditions for dry-farming, since May is drier than March and April; irrigation may be required.
- Swifter exposure to disease pressures.

Late-planting advantages include:

- Avoiding the first major generation of Colorado potato beetle (CPB)

After years of doing both, earlier plantings are preferred. The Colorado potato beetle is more easily managed than blights. Conducting proper scouting followed by timely spraying will keep this pest in check. But in some years, blight moves in too quickly and truncates the growing season as plants die back quickly, which is problematic if potatoes were planted late.

The field arrangement of the potatoes is carefully considered. The earliest potatoes are planted on the outside, and the varieties are lined up sequentially based on anticipated harvest date, from early to late.

Potatoes require 150 pounds of nitrogen per acre. Two-thirds of the fertilizer required is applied at planting with the Lilliston Rolling Cultivators, and the final third is applied with the Lilliston Rolling Cultivators at the first hilling cultivation.



Hiller discs cover the seed pieces.



Colorado potato beetle larvae.



Potato plant flowers.

CROP HANDBOOK: POTATOES

Family: *Solanaceae*

Cultural Practices

If a late, hard freeze is expected and potato leaves have already emerged from the soil, best practice is to place a row cover over the field. While this may not be practical, the risk of setting the plants back is substantial. In the past five years of planting early, the farm suffered a hard, late freeze only once. The plants were not covered, and all the greens died back. The plants rebounded and grew post-freeze, but yields were reduced substantially.

Prominent pests to monitor for include CPB; leafhoppers, which cause hopper burn; whiteflies; flea beetles; and aphids. Spinosad, *Beauveria bassiana*, and azadirachtin pesticides can be rotated for pest control, particularly for CPB. The primary

disease concern is early blight. Late blight, botrytis, and *Septoria* leaf spot may also cause issues, depending on the year. Copper and biofungicides can offer protection against blight and *Septoria*.

Potatoes are cultivated and hilled several times during the growing season. The Lely tine weeder will blind cultivate the plants when they are small. The hills will be knocked back somewhat, but at the early growth stage, it is effective at controlling weeds. As the plants grow larger, the more aggressive Lilliston Rolling Cultivators are used to hill and cultivate simultaneously. Ideally each bed will be hilled twice. A second fertilizer sidedressing will occur at the first hilling event.



Potato plants that underwent a late freeze. At this growth stage, they needed to be row covered.



Potato plants in this field are too large for any additional hilling.

CROP HANDBOOK: POTATOES

Family: *Solanaceae*



Blind cultivation with the Lely tine weeder.



Hilling, cultivating, and sidedressing with the Lilliston Rolling Cultivators.

CROP HANDBOOK: POTATOES

Family: *Solanaceae*



Two rows of potatoes in the middle of the field are starting to dieback, while potatoes on both the left and right are still green and growing.

Harvest

Once the plants begin dieback, a few plants are dug to check for harvest readiness.

Potatoes can stay in the field for several weeks after they are harvestable, but secondary rots are risked.

Plants are mowed with a tractor-mounted flail mower five to 10 days prior to harvest. This will aid in firming the skins of the potatoes.

When ready to harvest, the potato digger is attached to the narrow Kubota M8200 tractor. This digger harvests one row at a time. The digger is run at 540 PTO (power take-off). The machine is set into the field and lowered, but depth is important, as it can dig too much soil if lowered too deeply. The digger may get stuck, or large clods of soil may be drawn onto the conveyor. If there are a lot of weeds, they will also clog the machine. The side discs may need to be lifted with the hydraulics to prevent major clogging. Workers must keep toes and extremities away from the discs that are moving forward. If a worker needs to unclog the machine, the machine must be stopped completely for safety.



Potato harvest using the digger on the narrow Kubota M8200 tractor. Harvest buckets are spaced down the row.

CROP HANDBOOK: POTATOES

Family: *Solanaceae*

Hand harvest is still required, as the potatoes that have been dug will be carried along the digger's conveyor and then set on top of the soil. Therefore, potatoes are hand-picked from the surface and placed into red buckets. Full buckets are kept next to the row, and then the harvest wagon is driven down the row and buckets are loaded onto the wagon. Each bucket gets dumped into an empty macro bin that is set on the wagon. The person dumping the buckets counts each bucket that is placed into the macro bin. Each red bucket will hold 18 pounds of potatoes. A full macro bin will hold 1,000 pounds of potatoes. When growing multiple varieties, the macro bins are labeled with variety names.



The farm crew picks the potatoes from the soil surface into red buckets. The farm crew picks the potatoes from the soil surface into red buckets.



Red-skinned potatoes sit atop the soil after digging.



Full buckets of potatoes are emptied into a macro bin.

CROP HANDBOOK: POTATOES

Family: *Solanaceae*

Yield

Specialty potatoes will have the lowest yield. Magic Molly, for example, is a fingerling and yields about 0.8 pounds per row foot. Red-skinned Chieftain yields around 1.5 pounds per row foot, and the bulkier Kennebec and Elba can yield 1.5 to 2.0 pounds per row foot.

Overall, potatoes are included in CSA shares five to six times. The earliest potato, usually Red Gold, is often paired in CSA shares with the leeks. Each specialty potato is only distributed once. The staple potatoes, including Chieftain and the buff-skinned Kennebec and Elba, are handed out at least two times apiece when yields are good. For each distribution, members receive between three and four pounds of potatoes.

Post-harvest Handling

Potatoes are not washed at UK-CSA.

Storage

Potatoes are kept out of direct sunlight. They are stored in lidded macro bins in a climate-controlled facility. Ideal storage temperatures are cool, around 50°F. Potatoes that are kept over winter for the following year's seed are stored in a colder environment, ideally between 38°F and 40°F.

When potatoes are ready to be handed out, macro bins are brought to the packing shed. Tables are set up around each bin. Teams of three to five will divide the tasks of loading brown paper sacks with potatoes, and another person will weigh and adjust bag contents for the target weight. Bags are folded down and stacked in two layers in dark-green bins. Usually, 15 or 16 bags can fit per bin.



Potatoes are weighed and bagged for CSA shares.

CROP HANDBOOK: RADISH, RUTABAGA, AND TURNIP

Family: *Brassicaceae*

Varieties

Radish varieties grown include Rover, French Breakfast, Nelson, White Icicle, Easter Egg, Red Meat, and Alpine daikon winter radish.

The rutabaga variety grown is Helenor.

Turnips grown include Hakurei salad turnips and Purple Top White Globe.

Radishes mature between 21 and 30 days, except Red Meat and Alpine, which mature in 50 to 55 days. Rutabaga is also a storage crop and matures in 90 days. Salad turnips mature in as few as 38 days. Storage turnips like Purple Top White Globe mature in 50 days. Days to maturity are all calculated from direct seeding.



Hakurei turnips.



Nelson radish.



Red Meat radish, also called watermelon radish, features a bright pink interior.

CROP HANDBOOK: RADISH, RUTABAGA, AND TURNIP

Family: *Brassicaceae*



Helenor rutabaga.

Greenhouse Production

On occasion, Alpine winter radish and Red Meat radish are sown in the greenhouse in 162-cell Winstrip trays three weeks prior to transplanting. Transplanting these crops is done by hand and allows for managing proper spacing at planting. These varieties do equally well when direct seeded.

Field Preparations

Radishes, rutabagas, and turnips are usually direct seeded into bare ground.

Direct Seeding

Radishes, rutabagas, and turnips are direct seeded with the MaterMacc VegiMacc in the field or with the Jang push seeder in the biointensive system.

For the VegiMacc, radishes are seeded with plate 144, 2.5 and sprockets 22-17 for 0.8-inch spacing. Red Meat will use plate 96, 2.5 and sprockets 12-19 for 2.5-inch spacing to reduce thinning. Purple Top White Globe turnips use plate 48, 1.0 and sprockets 22-17 for 2.4-inch spacing. Hakurei turnips use plate 144, 1.0 and sprockets 12-23 for 2.0-inch spacing. Rutabaga uses plate 48, 1.0 and sprockets 17-22 for 4.1-inch in-row spacing, to minimize thinning.



Purple Top White Globe turnips.



Rutabagas need four to six inches between plants, as they quickly fill in the spaces as they grow.

CROP HANDBOOK: RADISH, RUTABAGA, AND TURNIP

Family: *Brassicaceae*

In biointensive seedings, Hakurei turnips are seeded using seed roller YYJ-24 with four rows per bed at one-inch spacing. Alpine radishes are seeded using seed roller X-12 with four rows per bed at two-inch spacing. Other radishes are seeded using seed roller MJ-24 or X-24 at one-inch spacing.

Turnips and all radishes require 50 pounds of nitrogen per acre rate, while rutabagas require 100 pounds of nitrogen per acre rate. All required fertilizer is applied at time of seeding or planting.

Earliest seeding for radishes in the field is March 10, and latest is September 15. Red Meat radish is only grown in fall to prevent bolting. Rutabaga is also only seeded in fall, around the beginning of August, for harvest before Thanksgiving. Turnips are seeded in both spring and fall, and the earliest field planting date recommended is March 10, but the latest recommended seeding date is August 10.

Cultural Practices

Flea beetles will feed on leaves of all direct-seeded brassicas. The damage is tolerated on radishes and rutabagas, as the greens are not kept or consumed by CSA members. However, the turnip greens are a choice item. Covering turnips with 47-gram ProtekNet netting will protect the plants from flea beetle damage and preserve the quality of the greens. Hoops are used to hold the net above the plants.



Turnips are harvested quickly by pulling several plants loosely at one time.

Harvest

Radishes, rutabagas, and turnips are all harvested in a similar manner. Two workers move their way down the bed on either side, pulling the roots out of the soil. Sometimes the harvest is selective, particularly with rutabagas. Most radishes and turnips are harvested en masse. To pull the crops out of the ground, wrap hands around greens toward the base and lightly pull up. It is easiest to grab greens from several plants at once to pull them together. The greens should not be gripped tightly or they will bruise. Piles are made for the cleaning crew to work next.



Loose turnips are laid on the soil surface for bunching.

CROP HANDBOOK: RADISH, RUTABAGA, AND TURNIP

Family: *Brassicaceae*



When bunching, cleaners remove yellow or damaged leaves from the crops. Once cleaned, several roots are banded together at the base of the leaves, closest to the root top, with either a rubber band or twist tie. In radish bunches, eight to 12 radishes go into a single bunch. With Hakurei salad turnips, they should be one and a half to three inches in diameter at harvest, and four to six turnips will go into a bunch. Purple Top White Globe turnips are larger than salad turnips and best harvested at three to five inches in diameter. If bunching these, three turnips are sufficient. Usually, Purple Top turnips are not bunched, but greens are cut off to leave roots only. For any crops that have greens trimmed, only a quarter inch of stem should be left attached.



Turnips are bunched in groups of five to six with rubber bands or twist ties.

French breakfast radishes are laid on top of the soil for bunching.

CROP HANDBOOK: RADISH, RUTABAGA, AND TURNIP

Family: *Brassicaceae*

Harvested roots and bunches are packed into harvest bins. Bunches are best packed upright for efficient use of bins.

When it is a very sunny and hot day, no more than half of a bed of these crops should be harvested at one time. Leaving roots on top of the ground to sit in the sun while waiting for the cleaning and bunching crew will cause them to wilt. Bunches with greens are set in the shade under the harvest wagon once a bin is filled.



Watermelon radishes are piled for clipping greens.



Bunched Rover radishes.



Alpine winter radishes pulled from a high tunnel bed.

CROP HANDBOOK: RADISH, RUTABAGA, AND TURNIP

Family: *Brassicaceae*

Yield

Radish yields 0.50 to 0.75 bunches per row foot, on average. Rutabaga yields 1.2 pounds per row foot, on average. Hakurei turnips yield 0.40 to 0.70 bunches per row foot. Purple Top White Globe turnips yield one pound per row foot.

In CSA shares, turnips are given out one or two times in spring and one or two times in fall. Radishes are grown for the CSA in spring one to two times, and in the fall, members receive radishes one to two times, including one distribu-

tion of Red Meat radishes. Rutabaga and daikon radish are only in fall shares, as they mature much later than the regular CSA season.

Post-harvest Handling

Radishes, rutabagas, and turnip roots are all washed in the barrel washer. Items are sorted and packed into light-green bins and weighed.



Loose roots are washed in the barrel washer, sorted, and weighed.

CROP HANDBOOK: RADISH, RUTABAGA, AND TURNIP

Family: *Brassicaceae*

Bunched radishes and turnips are washed on the bunched washing station. However, if the soil is minimal, radishes can also be washed using the rinse conveyor on the circulation setting. Bunched radishes pack well into yellow or light-green bins. Bunched turnips fit better into light-green bins.



Bunched turnips are washed at the bunched washing station.



Bunched radishes are packed into bins after washing.

CROP HANDBOOK: RADISH, RUTABAGA, AND TURNIP

Family: *Brassicaceae*

Storage

Brassica roots and bunches are all stored at 32°F. Bins are covered with plastic pallet covers to retain moisture.



Easter Egg radish bunch.



Hakurei turnip bunch.

CROP HANDBOOK: RHUBARB

Family: *Polygonaceae*

Varieties

The Victoria variety is grown at UK-CSA. This variety has more green-colored stems with pink blush at the base, rather than pink coloring along the entire stalk.

Field Preparations

Rhubarb does not like to get overheated. The plot for perennial production is prepped with repeated shallow cultivations to minimize the weed seed bank. Rhubarb is planted with white landscape fabric in between plant rows to deflect heat absorption. Black landscape fabric is placed underneath white to control weeds. Fabric is secured with sod staples every foot.



Mature Victoria rhubarb.



Rhubarb is planted on white landscape fabric that has a layer of black installed beneath for weed control.

Rhubarb requires 120 pounds of nitrogen per acre annually. Compost at a rate of 10 tons per acre and an annual required fertilizer amount is incorporated pre-planting. Annual fertilizer is applied next to the plant, but not directly on top of the crown. Fertilizer is lightly worked into the soil.

Transplanting

Rhubarb crowns are transplanted in March or early April, as soon as the ground can be worked. Crowns are buried with about one inch of the crown below soil level. Crowns are planted in rows five feet apart on center and three feet apart in-row.



Transplanting rhubarb crowns into white landscape fabric.



Adding annual fertilizer around the plant's crown.

CROP HANDBOOK: RHUBARB

Family: *Polygonaceae*

Cultural Practices

In-row, rhubarb is mulched to control weeds. Weeds between plants in-row are controlled through cultivation with scuffle and chop hoe as needed.

Rhubarb will sometimes set flower stalks in spring when under stress. Removal of each flower stalk at the base of the plant is necessary to ensure continued leaf production. Stalks

should not be cut off. Instead, the base of the stalk is grabbed with two hands and pulled upward while rocking it from side to side, until it is dislodged from the crown. Care should be taken to make sure that the base of the stalk does not break off, as a clean removal of the entire stalk is necessary. The field is monitored weekly in spring to remove flower stalks.



Rhubarb flower stalk.



Some plants produce one or more flower stalks.



All flower stalks are removed by pulling them from base, as the entire stalk must be detached from the mother plant.

CROP HANDBOOK: RHUBARB

Family: *Polygonaceae*



After four to five years of growth, rhubarb crowns can be divided. Another indication of needing to divide crowns is when the stalks themselves become numerous and thin. At least four to five buds are left on the original plant. A spade or shovel is driven vertically down into the root system to slice and divide. After retaining the original plant section of five buds or more, the extra plant may be divided into two or more clumps, with each clump bearing at least two to three buds. Divisions are replanted in holes left by plants that have died off, or they are planted to expand the area.

Japanese beetles are an occasional pest of rhubarb; however, usually no intervention is necessary, as only a few isolated plants are affected.

Harvest

Rhubarb stalks are harvested by hand, starting with a small harvest the second year and a full harvest in the third year. The largest and thickest stalks are picked from the plant and pulled from the base; ideally stalks are one inch across. Up to 50 percent of the stalks can be removed from a plant at a time. On average, eight to 12 stalks are removed from each plant. The leaves themselves of rhubarb are poisonous and are removed prior to washing and distributing. Workers use a lettuce field knife to chop the leaf off at the highest point on the stalk. Loose stalks are piled into harvest bins for transport out of the field.



Large rhubarb plants are divided in early spring, leaving at least five buds on original plant.



Japanese beetles are an occasional pest.



Rhubarb stalks are harvested by hand, pulling them at the base of the plant.

CROP HANDBOOK: RHUBARB

Family: *Polygonaceae*



Rhubarb leaves are removed by a lettuce field knife. Stalks are gathered into harvest bins.

Rhubarb is harvested between May and October, one to three times a year.

Yield

Each stalk weighs around 0.2 pounds. Yield for rhubarb is 0.2 to 0.55 pounds per foot, or one to three stalks per row foot per harvest.

Rhubarb is included in spring shares, as well as late summer or early fall shares. Rhubarb is best paired with strawberries or green onions for making pie and salsa. Each share includes between one half-pound and one pound of stalks, or approximately five to eight stalks. Stalks can be distributed loose or banded together with a thick rubber band.

Post-harvest Handling

Rhubarb stalks are cooled and washed on the rinse conveyor with the circulation setting. Stalks are counted and laid into dark-green bins. A bin can hold 100 stalks. Stalks can be trimmed if they cannot lay down flat inside the bins.



Rhubarb stalks being washed in the rinse conveyor.

Storage

Rhubarb is stored at 32°F. Plastic pallet covers are placed over the bins inside the cooler. Rhubarb will benefit from being stored upright in one inch of water as well for maximum freshness.

Rhubarb stores for two weeks.



CSA members receive a half pound to one pound of bunched stalks in a share.

CROP HANDBOOK: SUMMER SQUASH, PATTY PAN, AND ZUCCHINI

Family: *Cucurbitaceae*

Varieties

Spineless varieties are preferred for ease of harvest, and they are also reliable performers.

Yellow squash varieties grown include Lazor, Slick Pik YS 26, Multipik, and Smooth Operator. Zucchini varieties grown

include Spineless King, Spineless Perfection, and Green Machine. Patty pan types grown are Y-Star, which is heavy yielding but turns green under heat stress, and Sunburst.

All of these crops mature in 25 to 35 days from transplant.



Yellow summer squash, ready for harvest.



Zucchini still has its flower bloom attached.



Patty pan squash, starting to grow.



Pollinators frequent the squash blooms.

CROP HANDBOOK: SUMMER SQUASH, PATTY PAN, AND ZUCCHINI

Family: *Cucurbitaceae*

Greenhouse Production

Summer squash, patty pan, and zucchini are hand-seeded into 72-cell Winstrip trays. Plants require only three weeks in the greenhouse, as they are fast growing and will get leggy quickly.



Squash plants only grow for three weeks in the greenhouse.



Summer squash at 10 days of growth.

Field Preparations

These crops are fast growing and short-lived, due to disease and insect pressures. For successful establishment, they are grown on aluminized plastic mulch beds. No living mulch is planted. Plastic beds are cultivated several times prior to planting. Each field holds six or seven beds spaced at least eight feet or seven feet apart respectively for summer squash, patty pan, zucchini, and cucumber.

Summer squash, patty pan, and zucchini require 100 pounds of nitrogen per acre. All required fertilizer is applied at time of plastic laying.

Transplanting

Earliest planting date is May 10, and latest is August 1. Summer squash is planted in early May and planned for four consecutive weeks of harvest, followed by a break of two to three weeks. A second planting occurs around late June for three to four more weeks of harvest in late July and early August.

Summer squash is transplanted using the Rain-Flo water wheel setter, in a single row per bed at 15-inch in-row spacing.

Cultural Practices

Plastic beds are cultivated one or two times after planting, until plants become too large to cultivate over them.

Summer squash, patty pan, and zucchini are routinely attacked by cucumber beetles and squash beetles. Kaolinite clay is sprayed on the leaves weekly, or as needed to deter feeding.

Common diseases on summer squash include powdery mildew and downy mildew. Fungicides are rarely applied since plants are so fast growing and short-lived.



Kaolinite clay is still visible on the summer squash planting and the plastic mulch.

CROP HANDBOOK: SUMMER SQUASH, PATTY PAN, AND ZUCCHINI

Family: *Cucurbitaceae*

Harvest

Summer squash and zucchini grow an average of one inch per day. They are harvested three times a week on Mondays, Wednesdays, and Fridays. Fruits are harvested using small harvest knives to cut the fruit at the stem from the plant. Workers must be careful to not let the plant's spines cause injury to the fruit's skin. Workers will benefit from long sleeves to prevent skin irritation during harvest. Two harvesters walk on either side of each bed.



A small knife cuts a zucchini at its stem.



The zucchini is gently placed in a red bucket.

CROP HANDBOOK: SUMMER SQUASH, PATTY PAN, AND ZUCCHINI

Family: *Cucurbitaceae*



Patty pan harvest.



Yellow summer squash harvest from plants growing out of the clay protectant.

CROP HANDBOOK: SUMMER SQUASH, PATTY PAN, AND ZUCCHINI

Family: *Cucurbitaceae*

Summer squash and zucchini are harvested when five to seven inches long, and patty pan when three to four inches in diameter. Oversized squashes and zucchinis are removed from the plants and tossed in the drive rows. Flowers that are still attached to the end are pulled off at harvest, as they

may not dislodge during washing. Harvested crops are gently placed into red buckets. Full buckets are handed off between workers and set down at the edge of the field for pick up with the harvest wagon. The conveyor is also sometimes used to pick up buckets after harvest.



Workers are passing buckets of squashes to field edge for pick up.



Zucchini measures six to eight inches at harvest. Yellow summer squashes may be harvested as small as five inches.

CROP HANDBOOK: SUMMER SQUASH, PATTY PAN, AND ZUCCHINI

Family: *Cucurbitaceae*



Patty pan squashes vary in size from 3.5 inches to five inches in diameter.

Yield

Yellow squash yield 0.8 to 1.0 fruits per row foot; zucchini yields 0.6 to 0.9 fruits per row foot; and patty pan squashes yield 1.0 to 1.2 fruits per row foot.

Yellow squash and zucchini are given out in CSA shares three to five times in the early season. For the second planting of yellow squash, zucchini, or patty pan squashes, they are given out for another three to four weeks. Each share receives one to four squashes per distribution.

CROP HANDBOOK: SUMMER SQUASH, PATTY PAN, AND ZUCCHINI

Family: *Cucurbitaceae*

Post-harvest Handling

Summer squashes are all washed in the brush washer. After washing, squashes are sorted and counted into light-green bins. Bins are labeled with the number per bin, which faces out when they are stacked in the cooler.



Squashes are loaded into the brush washer for washing, sorting, and packing.



Bins of squashes are labeled with their quantity facing outward for double checking and dividing harvests for CSA locations.

CROP HANDBOOK: SUMMER SQUASH, PATTY PAN, AND ZUCCHINI

Family: *Cucurbitaceae*

Storage

Summer squashes are optimally stored at 41°F to 50°F. No plastic pallet covers are required.

Summer squashes are stored for one to two weeks.



Green Machine zucchini.



Multipik yellow summer squash.



Sunburst patty pan squash.

CROP HANDBOOK: SWEET POTATOES

Family: *Convolvaceae*



Two Covington sweet potatoes, freshly dug.

Varieties

Sweet potato varieties grown include Covington, Orleans, and Murasaki. Covington is the preferred variety. Murasaki is a Japanese variety with purple skin and white flesh; tubers are smaller and yield is overall much less than either Covington or Orleans.

Sweet potatoes are purchased as slips, which are vegetative shoots from a sweet potato tuber. When the field is not ready, the slips can be held in a 55°F cooler for one to three days by wrapping roots in damp paper towels. If the slips need to be held longer, they can be heeled in a trench for holding up to a week.



The slips on left were compromised during transit, most likely from heat. The rotted slips were not planted. Normal slips look like those on right.

CROP HANDBOOK: SWEET POTATOES

Family: *Convolvulaceae*



Slips wrapped in damp paper towels are being held in the cooler until planting.



Slips are heeled in, the practice of covering the plant roots temporarily for protection before transplanting to their permanent location.

Field Preparations

Sweet potatoes are planted on black plastic mulch. No living mulch is grown, due to the rapid vining of the sweet potato plants.

Sweet potatoes require 40 pounds of nitrogen per acre. All fertilizer required is applied pre-planting at time of plastic mulch installation.

CROP HANDBOOK: SWEET POTATOES

Family: *Convolvulaceae*



Newly transplanted sweet potato slips on black plastic mulch.

Transplanting

Sweet potatoes are planted with one row per bed and nine-inch in-row spacing, using the Rain-Flo water wheel setter. Slips are spindly, so care is taken not to bend and break them. When bed top is moist underneath, it is easy to push the slip into the soil and pack soil around it to ensure it is secure.

Earliest planting date is May 10, and the latest is June 10. Sweet potatoes are usually planted around May 20–25.

Cultural Practices

Plastic mulch beds are cultivated with the plastic cultivator two to three times. Once the vines have grown off the bed tops, a final cultivation can occur, which will rip some of the leafy vines, but the plants are quite vigorous and can withstand this late cultivation disturbance.



A sweet potato slip putting on new growth.

CROP HANDBOOK: SWEET POTATOES

Family: *Convolvulaceae*



The vines are spreading quickly, but bare soil is still visible in the aisles. These beds can be cultivated in one final pass. Some vines will be torn, but the crop will not be harmed.

Very few insect pests and diseases harm sweet potatoes. The primary pest of sweet potatoes are voles that live underground and chew on mature tubers. Trapping in spring and crop rotation are the primary methods for addressing vole issues. Eliminating plastic mulch and growing sweet potatoes on bare ground is another method.

Harvest

Sweet potato greens can be harvested when vines are full, in July or early August, to get a second crop for CSA shares. Clip individual leaves at the ends of vines to get the more tender leaves. Leaves should not be washed, as they are easily damaged and will become water-soaked. Bundle or bag greens and keep in cooler at 32°F until distribution.



Leaves from flowering sweet potato vines are harvested selectively into bins in early August.



A handful of sweet potato vine leaves can be included in CSA shares in midsummer.

CROP HANDBOOK: SWEET POTATOES

Family: *Convolvulaceae*



Checking on sweet potato tuber sizing. Each plant should produce one to two large sweet potatoes and a few smaller ones. These tubers are ready for harvest.

In late August or early September, plants are selectively dug with a hand shovel to check for tuber sizing. Sweet potatoes can quickly grow to beyond target size if not harvested in a timely fashion.

When tubers have reached mature size, sweet potato vines above ground are mowed with a flail mower atop the beds. Plastic beds are lifted with a Rain-Flo Plastic Challenger Model 1800 mulch lifter.



Black plastic and vine residue sits on top of the tubers after mulch is lifted.

CROP HANDBOOK: SWEET POTATOES

Family: *Convolvaceae*



Tubers still attached to vines can be hand-pulled from the vines.

Red buckets are used to hold the sweet potatoes that are picked up by hand. Workers wear nitrile gloves to prevent sweet potato sap from staining hands. Buckets are dropped along the field edge for easy grabbing and filling. Harvesters locate the top stem, which may still be emerged through the plastic hole. Beneath the plastic, attached to the stem, will be the sweet potatoes. Individual potatoes are twisted off by hand to separate them from the stems. Potatoes are placed in the buckets. Some potatoes will have dislodged from the stems and may remain in the soil. Harvesters use their hands to dig beneath the lifted plastic and search for any roots still buried.

All sweet potatoes are inspected at harvest. Significant vole damage is one cause to cull the fruit. Smaller bite marks on the potatoes are tolerated and sold as “seconds.” A clean cut on the potato will heal over during curing. Any potatoes damaged by the mulch lifter are discarded. Any potatoes with soft spots are usually readily apparent and discarded.



While edible, CSA members do not want overly large sweet potatoes.

CROP HANDBOOK: SWEET POTATOES

Family: *Convolvaceae*



Harvesters fill red buckets with sweet potatoes before being unloaded into a macro bin.

Once red buckets are full, the harvest wagon is driven down the drive row and buckets are passed over to the wagon. Each bucket is dumped into a macro bin.

Yield

Sweet potatoes grown with one row per bed yield on average three pounds per row foot. Sweet potatoes can be grown with two rows per bed; however, the yield per row foot will be reduced.

Sweet potatoes are given out three times in CSA shares. The first share of the year will receive sweet potatoes that have been stored over winter. The other two distributions are in the last month of shares, after the curing process has been completed. Sweet potatoes are also a staple crop for Thanksgiving and fall CSA shares. Each share receives three to four pounds of sweet potatoes at a time.



Plastic mulch can be pulled up prior to loading the potatoes in buckets for easier harvest. Only beds that will be promptly harvested are mowed at one time.

CROP HANDBOOK: SWEET POTATOES

Family: *Convolvaceae*



Sweet potatoes after curing in the greenhouse are weighed and packed in brown paper bags.

Post-harvest Handling

Sweet potatoes are not washed, but they do require curing. Macro bins are lidded and taken to the greenhouse for curing. The ideal temperature for sweet potatoes to cure is 70°F. At lower or variable temperatures, the curing process will be slowed. Sweet potatoes are cured after 10 to 14 days and then handed out in CSA shares. Once cured, the sweet potatoes will have developed their sugars, the skins will be firm, and they will be ready for storage.

For CSA distribution, sweet potatoes are weighed into brown paper bags. Paper bags are folded down and set in dark-green bins. About 12 to 14 bags will fit in a bin, split between two layers.

Storage

Sweet potatoes are ideally held at 55°F to 60°F with high (80 to 85 percent) relative humidity. A temperature-controlled environment is preferred for long-term storage. Macro bins are stored over winter in a climate-controlled area, or in UK-CSA's Cooler 2 set at 55°F, so as not to suffer cold damage. Sweet potatoes will store for six to nine months or more. The bins are checked during winter for any molding or decaying tubers; tubers that are decaying are removed from the storage bins.



CSA members receive three to four pounds of sweet potatoes for each share distribution.

CROP HANDBOOK: TOMATOES

Family: *Solanaceae*

Varieties

The majority of tomato varieties grown for CSA are indeterminate in order to capitalize on the longest growing season. At UK-CSA, tomatoes grown include hybrids, heirlooms, and paste, as well as varieties suited for you-pick. CSA customers enjoy the flavor from heirlooms, but these varieties are more challenging to grow. Therefore, offerings are diversified with more reliable varieties. The tomato mix breakdown for all plantings is as follows: hybrids are 40 to 45 percent, heirlooms are 30 to 35 percent, and paste are 25 to 30 percent. You-pick varieties are not included in these percentages. You-pick types include cherry, grape, cocktail and saladette tomatoes that are smaller and better suited for you-picking.

Hybrid varieties regularly grown include Big Beef, Park's Whopper, New Girl, Mountain Merit, Mountain Princess, Defiant, and Chef's Choice Orange. Super Choice, Costoluto Genovese, German Johnson, Vinson Watts, Pineapple Premier, Striped German, and Valencia varieties are grown for heirlooms.



Tomato varieties grown at the CSA.

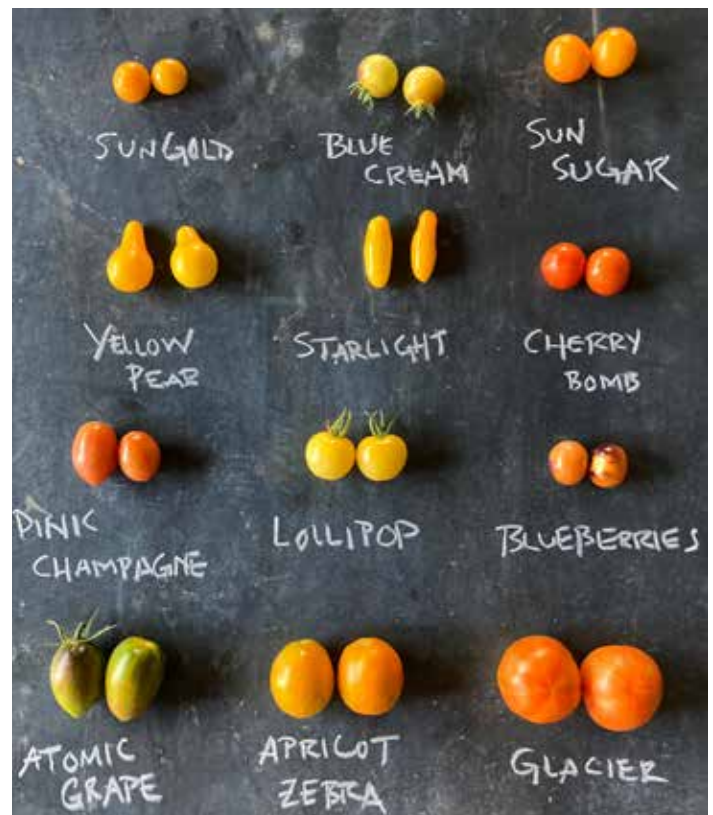
Amish Paste, Speckled Roman, San Marzano II, and Plum Regal varieties are grown for paste tomatoes.

Yellow Pear, Sun Gold, Sun Sugar, Pink Champagne, Juliet, Green Zebra, Glacier, Lollipop, and Matt's Wild Cherry varieties are grown for you-pick.

The earliest tomatoes ripen in 55 to 60 days. The larger beefsteak and slicing tomatoes generally ripen in 65 to 75 days. Some larger heirlooms and paste tomatoes may take as long as 78 to 85 days. All days to maturity are from transplant.

Greenhouse Production

Tomatoes are started in 162-cell Winstrip trays, with two to three seeds per cell. Tomatoes will benefit from being on a heated mat at 70°F until they germinate, after which they should be taken off the heat mat. The tomatoes are potted up into 50-cell Winstrip trays when true leaves emerge on the seedling. Plants are typically ready for transplanting in five weeks.



Varieties planted in the you-pick field.

CROP HANDBOOK: TOMATOES

Family: *Solanaceae*



Teff living mulch being established.



Tomato transplant.

Field Preparations

Early tomatoes are planted on black plastic mulch. Later tomatoes can be grown on either black or white plastic mulch. When grown in the high tunnels, black woven landscape fabric is used instead of single-use plastic mulch. Tomato beds in the field are spaced 10 feet apart, center to center, for air flow. Teff living mulch is established between the beds.

Tomatoes require 125 pounds of nitrogen per acre. Two-thirds of the nitrogen requirements is applied pre-planting at time of plastic laying. The remainder is fertigated after eight to 10 weeks of growth.

Transplanting

Tomatoes are transplanted after last frost, sometime after April 25. A succession planting is planted three to four weeks later, or any time prior to July 1.

In the field, tomatoes are planted using the Rain-Flo water wheel setter. Plants are in a single row, spaced 18 inches apart in-row. A gap of two plants is left in the middle of the bed (150 feet from end) to act as a pass-through for workers. In high tunnels and Haygrove systems, plants are hand-planted and spaced 24 inches apart in-row. Five rows will fit the width of either structure.

The transplant is buried as deeply as possible, up to the first set of leaves if able. The deeper the plant, the stronger the root system that will develop.

Cultural Practices

Shortly after planting, T-posts are installed into the bed. At the beginning of every season, T-posts are sanitized either by dunking in a bleach solution in a bucket loader or using a power washer to spray off the T-posts with a bleach solution. This helps to ensure no pathogens can persist if they have overwintered on residual soil still left on the metal T-posts. In addition, reusable landscape fabric is sprayed or soaked in a bleach solution before installation in the high tunnel.

T-posts at installation are placed after every two plants. Workers installing T-posts must make sure the drip irrigation line buried in the bed is not punctured. All T-posts face the same direction. The posts are centered with the row of plants, which will help with tomato tying.

Tomatoes are tied using the Florida weave. See [SOP: Tomato Tying](#).

Tomatoes are tied weekly as they grow, and sometimes more frequently during growth spurts. Each successive tie is spaced about four inches above the preceding one. The tomato stem must be captured and held up by the twine during tying. The next strings are simply run on the outside of the plants and held in place by circling the T-posts. Plants are

CROP HANDBOOK: TOMATOES

Family: *Solanaceae*



Metal T-posts being sanitized before installation.



Workers wear ear protection when installing T-posts, spaced two plants apart.



Tomatoes are tied up with twine weekly.

sandwiched between two lines of twine, with one on front and one on back; no crossover is made. It takes about 15 to 20 minutes to completely tie a half row of 150 feet of tomatoes. Workers stop the tying at the midpoint in the field and circle back to tie down the other side, in order to preserve the two-plant gap at the middle of the bed for a pass-through.

When determine tomato varieties are grown, these plants do not grow nearly as tall as indeterminate types. It is advantageous for tying purposes to group all determinate varieties together, as they will be tied similarly. The height of plants of indeterminate varieties will also vary from variety to variety. The “rampancy,” or final plant heights, of tomatoes is noted for the tomato varieties chosen. For field plans, tallest plants are situated on the north and west sides of the fields. Tallest plants are grouped in the same row if possible, according to ascending rampancy. (See the [Pam Dawling rampancy rating list](#).)

In addition to tying tomato plants, tomatoes are suckered to encourage plant vigor. Suckers emerge in the crotch angles of the plants. Sucker at the first sign of flower blossoms on the plants. The first bloom set, which is closest to the bottom of the plant, is located first. One sucker below that first bloom cluster is left on the tomato plant. All other suckers below that



The flower clusters are small and yellow. They are used as a reference point to remove suckers below them.

CROP HANDBOOK: TOMATOES

Family: *Solanaceae*

one are removed. In addition, any suckers emerging from the base of the plant at soil level are removed. Removal is done by hand, by pinching. Larger suckers are best removed by pruners. Suckering may be needed weekly to keep plant vegetative growth in check.

Tomatoes are susceptible to many types of foliar and soil-borne diseases. The primary tomato issues are early blight, late blight, *Cercospora* leaf spot, and bacterial speck. In addition, nutrient and water imbalances can cause blossom end rot, yellow shoulder, catfacing, cracking and splitting. The best organic practices are prevention of issues that are spread by wind and water. Susceptible tomato varieties, like heirlooms, are grown under cover in a Haygrove or high tunnel system to prevent these problems from arising. The tunnel environment also allows for an earlier planting date for the first round of tomatoes. Tunnel tomatoes are rarely sprayed with fungicides or insecticides.

In open-field production, a protective copper spray is applied every seven to 14 days, or as needed, e.g. prior to a rain-fall event. In addition, some biofungicides are efficacious at improving plant vigor and performance. Some of these can be used in conjunction with protective sprays. A 10-foot bed spacing is followed to maximize air flow. If disease issues intensify, plants can be spaced 24 to 36 inches apart for more air flow. In addition, plants are rotated away from other solanaceous crops. The first and second tomato plantings are situated in different fields to reduce disease pressure on the later-planted tomatoes.

Grafting tomato plants is one way to mitigate soilborne diseases for tomatoes grown under cover, when rotation options are limited. A disease-resistant rootstock is selected to pair with susceptible plants. Successful grafting relies on a stable graft union by matching plants with similarly sized stems. Therefore, some trials are recommended each year to ensure the rootstock and susceptible tomato varieties will align in their growth stage for successful grafting. Rootstock varieties include Shin Cheong Gang, Maxifort, and Estamino; however, our limited trials have shown that Estamino is slower growing than most of the susceptible fruiting tomatoes and should be started earlier than the susceptible variety.

Primary pests that require plant monitoring include aphids (look under plant leaves, use insecticidal soap to control as needed); tomato hornworm (frequently late in the season and will be parasitized, so damage is minimal); and tomato fruitworm (use Bt for late-season tomatoes to control).

When the field is being taken out of production, tomato string is removed first before clearing the field. Workers use a pocket knife or hand shears while walking down every tomato row and slice the string along the edge of every other T-post, from top to bottom. Workers then walk to the T-post in between each cut one and pull the string out. After all string has been removed and disposed, T-posts are removed using a T-post remover. Gloves are recommended. At this point, plants are mowed, and then plastic is lifted and removed as usual.



While grasshoppers are frequent visitors in the tomato field, they do not cause significant damage.



The green hornworm is parasitized. These worms are seldom a pest issue due to biocontrol organisms like parasitic wasps.

CROP HANDBOOK: TOMATOES

Family: *Solanaceae*

Harvest

Tomatoes are harvested twice a week, on Mondays and Thursdays. Ideal ripeness is 50 percent or more.

Tomatoes are pulled gently off the vine. The calyx of the stem is removed if it stays attached to the tomato at harvest, as this can degrade in storage. Tomatoes are always set gently down on their shoulders in the bins.

Hybrids and paste tomatoes are stacked in two layers in bins. Heirlooms are only stacked in a single layer. When double stacking, less-ripe tomatoes are placed on the bottom layer.

Yellow bins or bread trays are used to hold tomatoes; yellow bins can hold two layers, while bread trays can only hold single layers and are best used for heirlooms.



Harvesters start at one end of the field.



Tomatoes are stacked in single layers in bread trays.

CROP HANDBOOK: TOMATOES

Family: *Solanaceae*



A sled is used to hold tomato harvest bins.



An ATV can fit between tomato beds to pick up full bins, if needed.

Bins are carried through the field or pulled with a sled tied to the harvester's belt. The sled will allow both hands to be free for harvest. When bins are full, they are placed on top of the plastic mulch shoulders in the shade for pick up by ATV, or they are carried to the harvest wagon using the plant gap at the middle of the rows. At the harvest wagon, each bin is weighed and labeled with the weight. The weight is recorded in the harvest log. Tomatoes are kept shaded by placing an empty bin on top of the full bins.

Yield

Paste tomatoes average 10.4 pounds per plant. Hybrid tomatoes average 10.2 pounds per plant. Heirloom tomatoes average 9.2 pounds per plant. These averages represent marketable fruit.

Each year, around 1,285 tomato plants are grown for a 250-member CSA. Over 1,000 of these are planted in an open-field environment, while around 275 are planted under cover in a Haygrove or high tunnel system. These plants produce fruit totaling more than 13,000 pounds or more each year. Tomatoes are given to CSA members for 12 to 14 consecutive weeks, from July to October. Over the course of a season, CSA members receive around 50 pounds of tomatoes. Each week, members receive between one and six pounds of tomatoes. The goal is to deliver 2.5 to 3.5 pounds a week, but some weeks are lighter, and others are heavier as plants ramp up and when the second planting starts to produce more.

CROP HANDBOOK: TOMATOES

Family: *Solanaceae*

Post-harvest Handling

Tomatoes are not washed. However, they are wiped down with a dry cloth if needed.

Some sorting of tomatoes harvested before the day of distribution is required. Any tomatoes that are 80 percent ripe or more with bruising, cracks that are not fully healed, or other deformities are sorted out of the marketable CSA fruits and set aside to be sold as “seconds” for canning. Boxes of 25 pounds of canning tomatoes are assembled.

Storage

Tomatoes are not refrigerated below 50°F. However, they are safely stored at 55°F. Storage is beneficial for tomatoes to minimize loss and damage. If they are stored at 55°F, some condensation may occur when the tomatoes are removed from storage depending on ambient air temperatures. To minimize condensation, tomatoes are pulled out the night before packing them for the CSA. Stacks are kept at ambient temperature in the packing shed. If small mammals are a concern, the stack of tomato bins is covered with a plastic pallet cover and the edges are tucked under bins to keep any unwanted visitors out.



Red, ripe tomatoes.



Tomatoes are covered with plastic in the packing shed prior to distribution.



Underripe tomato, which is not ready to harvest.

CROP HANDBOOK: TOMATOES

Family: *Solanaceae*



Tomato at 50 percent ripeness. All tomatoes must be at this level of ripeness or greater at harvest.



Hybrid and paste tomatoes at 75 percent or more ripeness.

CROP HANDBOOK: WATERMELON

Family: *Cucurbitaceae*

Varieties

Only diploid watermelons, which contain seeds, are grown. Triploid, or seedless, watermelons are not grown due to space requirements for non-productive pollenizer plants. Sugar baby watermelons are round and smaller, at seven to 10 pounds each, which is ideal for CSA shares. They are very sweet but do contain many seeds. Blacktail Mountain is the favorite variety.

Yellow- and orange-flesh watermelons are specialty types. New Orchid and Sorbet Swirl have performed well. Flavor is very good for both.

Larger watermelons are seldom grown, due to storage limitations. Both Sangria and Moon and Stars heirloom varieties have produced nice melons when larger types have been grown.

Watermelons mature in 75 to 80 days from transplant.



New Orchid watermelons have a yellow flesh.



Blacktail Mountain sugar baby watermelons.



Moon and Stars heirloom watermelons may weigh 30 to 40 pounds apiece.

CROP HANDBOOK: WATERMELON

Family: *Cucurbitaceae*

Greenhouse Production

Watermelons are hand-seeded into 72-cell Winstrip trays. Seedlings are prone to aphid attacks, so plants are monitored closely. Plants require four weeks in the greenhouse.

Field Preparations

Watermelon is grown on black plastic mulch beds. No living mulch is planted. Plastic beds are cultivated several times prior to planting. Each field holds six or seven beds for melons, spaced at least eight feet or seven feet apart respectively.

Watermelon requires 120 pounds of nitrogen per acre. All fertilizer required is applied at time of plastic laying.

Transplanting

Earliest planting date is May 5, and latest is July 1.

Watermelons are transplanted using the Rain-Flo water wheel setter, in a single row per bed at 24-inch in-row spacing.

Cultural Practices

Plastic beds are tractor-cultivated two to three times after planting, until vines spread off the bed. A final cultivation can be done by manually moving any vines that have fallen off the bed top back onto the bed. After this final cultivation, the plant is left to grow into the rows and shade out weeds. The field is monitored for larger weeds. Any larger weeds are selectively removed by hand or chop hoe. Workers are careful when walking into the field to minimize damage to fruits or vines.

Watermelons are much hardier than cantaloupes. Crops are monitored closely when young for aphids. Beneficial insect releases are sometimes made, but without netting there is no guarantee the insects will stay nearby. If available, netting is used on plants when small and removed when ready for pollination. If aphids are problematic on young watermelon plants, insecticidal soap is sprayed to knock the population back.

Irrigation is withheld in the last two weeks of maturation to increase melon sweetness.



A baby watermelon begins to grow.

CROP HANDBOOK: WATERMELON

Family: *Cucurbitaceae*

Harvest

Watermelons are harvested in the field using the harvest conveyor. The conveyor wagon should be preset with two macro bins situated on either side of the conveyor prior to being taken to the field. Workers walk in between each bed and check both beds on left and right, as well as the area in between, for melons ready to harvest. Harvest is selective for ripe watermelons.

Harvest indicators include the size of melon, a hollow sound when melon is thumped on the exterior, and a desiccated tendril located at the first node away from the fruit's stem. There will also frequently be a yellow spot on the bottom of the melon, which is an indication of its maturity. To determine the best melon size for harvest, two to three melons of various sizes are cut open in the field to check for internal coloration. Flesh should have full, deep color and taste sweet.



A yellow spot on the bottom of the melon is another harvest indicator.



A dried tendril is one harvest indicator.



The taste test is always a good method to determine readiness.

CROP HANDBOOK: WATERMELON

Family: *Cucurbitaceae*

Melons are removed from plants by hand, by gently pulling the stem away from the top of the fruit. Melons are gently placed individually onto the conveyor. The conveyor will carry the melons to the harvest wagon, and workers place melons into macro bins. Melons should not be dropped into the bins, as they can crack. When field conditions do not require melons to be washed, they are counted at time of harvest by the worker placing them into the macro bins.



A conveyor helps with transferring melons to macro bins.

Yield

Sugar baby watermelons yield 0.75 to 0.85 fruits per row foot. Specialty melons and larger varieties may only produce 0.25 to 0.30 fruits per row foot.

Watermelons are given out in CSA shares two to three times a year. Each share receives one melon per distribution.

Post-harvest Handling

Watermelons are washed in the brush washer to remove soil on the exterior skin, if needed. If washing is not necessary, watermelons are kept in a clean macro bin and moved to the cooler for room cooling.

Storage

Watermelon is optimally stored at 55°F. They are very sensitive to ethylene and need to be kept away from ethylene-producing fruits and vegetables. After field heat is removed, plastic pallet covers are placed over the tops of the macro bins.

Blacktail Mountain variety of watermelon can be stored for three to four months under optimal conditions. This storage life allows for flexibility with share distribution. However, space for one to two macro bins in the cooler is required to keep them housed.

Most other watermelons store well for two weeks.



Watermelons are kept in macro bins and moved into the cooler using a pallet jack.

CROP HANDBOOK: WINTER SQUASH AND PUMPKIN

Family: *Cucurbitaceae*

Varieties

Only Moschata and Pepo types of winter squash are grown at UK-CSA, but several varieties within these genres are grown annually. The preferred hallmark varieties include Waltham and Honeynut (butternut); Tiptop and Table Ace (acorn); Delicata JS and Jester (delicata); and Pinnacle or Spaghetti Squash (vegetable spaghetti or spaghetti squash).

Most winter squashes take 85 to 105 days to maturity from direct seeding, or 75 to 90 days from transplant.

Pie pumpkin varieties include Cinnamon Girl PMR and Baby Pam. Pie pumpkins mature in 85 to 99 days from direct seeding, or 75 to 89 days from transplant.

Greenhouse Production

Winter squashes are hand-seeded into 72-cell Winstrip trays in ProMix media, instead of our standard potting media. ProMix is used for these crops because of their fast and vigorous growth, which does not depend upon robust fertility in the tray. Winter squash and pumpkin only require three weeks in the greenhouse, as they are fast growing and will get leggy quickly.



Winter squash only grows in the greenhouse for three weeks.

Field Preparations

Winter squash can be grown on white plastic mulch, but due to insect pressures they are best grown on aluminized plastic mulch beds. Row covering at time of planting will also be beneficial, but it is not required. Plastic beds are cultivated several times prior to planting. Each field holds six or seven beds for winter squashes, spaced at least eight feet or seven feet apart respectively.

Both winter squash and pumpkin require 100 pounds of nitrogen per acre. Granular fertilizer required to meet crop needs is all applied at time of plastic laying.

Transplanting

Earliest planting date is May 5, and latest is June 15 for pie pumpkin and July 1 for other winter squashes.

Winter squashes are planted with the Rain-Flo water wheel setter, with one row per bed at 15-inch in-row spacing. Pumpkins require more space and are planted with 30-inch in-row spacing.



Winter squash is transplanted with a water wheel transplanter.

CROP HANDBOOK: WINTER SQUASH AND PUMPKIN

Family: *Cucurbitaceae*



The foliage is no longer protecting this spaghetti squash from sunscald.

Cultural Practices

Netting will help all winter squashes when available, but pumpkins get priority for netting. All winter squashes are grown on aluminized mulch for insect control when able. Any nets are removed once plants are flowering for pollination.

Major pests of winter squash are cucumber beetles and squash beetles. Kaolinite clay is sprayed on the leaves weekly, and more frequently as needed after heavy rains, to deter feeding.

Powdery mildew is the biggest disease issue. Fungicides are applied regularly, since plants have to survive for a very long time. When plant foliage dies back, fruits are at risk of sunscald and are harvested quickly.

Plastic beds are tractor-cultivated until plants vine out off the beds, or until plants are too tall for the cultivator to pass over top of them.

Harvest

Winter squashes are harvested when the skin has developed 75 percent or more of its coloring. If plant foliage has begun to die back, fruits are susceptible to sunscald and are taken early. Fruits will ripen further in storage.

Winter squashes are harvested using pruners. Workers may want to wear gloves and long sleeves to prevent skin irritation from the plant foliage. A small stem of one-half to one inch is left on each squash; pumpkins can have a longer handle of two to three inches. Workers walk on either side of each winter squash bed. Squashes are grouped into piles every five to 10 feet on top of the bed. After the field is harvested, squashes are picked up with the harvest conveyor. Workers follow behind the conveyor to place the squashes on top of the belt. The wagon is pre-set with two macro bins, and squashes are sorted by type into the macro bins and counted. Best practice is to set the squashes into the bins and not drop them.



Squashes are clipped from vines and stacked on top of beds.

CROP HANDBOOK: WINTER SQUASH AND PUMPKIN

Family: *Cucurbitaceae*



Squashes are placed on the conveyor and counted into macro bins.

Yield

Delicata varieties yield up to 1.8 to 3.0 fruits per row foot. Spaghetti squash yield 0.4 to 1.25 fruits per row foot. Acorn yield 0.9 to 1.0 fruits per row foot. Butternut yields 2.0 to 2.5 fruits per row foot. Pumpkin yields 0.6 to 1.3 fruits per row foot.

Each type of squash is destined for CSA shares once, with the exception of butternut, which is included twice. Overall, winter squashes are included seven to eight times in shares during the course of the CSA season. CSA members usually receive two winter squashes for each distribution, except delicata and honeynut, for which four are given out each time.

Post-harvest Handling

Winter squashes are all washed in the brush washer with a SaniDate sanitizing spray. After washing, they are sorted and counted into macro bins. Bins are labeled with the type and number of squashes. When squash is ready to hand out, the number needed for distribution is counted into dark-green bins.

Butternut squashes benefit from a curing period in a warm environment with good air circulation for four weeks to develop sugars. Honeynut and pumpkin also develop full color after two to three weeks of curing. Other squashes do not need to cure and can be given out right after harvest.

Storage

Winter squash and pumpkin are optimally stored at 50°F to 55°F. Macro bins are lidded but no plastic pallet covers go over the dark-green bins.

Depending on quality, winter squash and pumpkin are stored for one to six months or more. Squashes are checked regularly for any that are turning soft. Soft ones are removed immediately to compost.



Squashes are stored in macro bins until distribution.

CROP HANDBOOK: WINTER SQUASH AND PUMPKIN

Family: *Cucurbitaceae*



Jester delicata.



Waltham butternut.



Honeynut.



Delicata JS.



Tiptop acorn.



Cinnamon Girl PMR pie pumpkin.

Standard Operating Procedures (SOPs)

In this section, a series of SOPs cover on-farm operations as well as management of different aspects of CSA production. These SOPs are site-specific to the UK-CSA, and they reference specific locations and on-site practices. The SOPs can be used as a guide for different farms but would require modification in the context of another operation.

To skip directly to a specific SOP section in this document, click on the bolded title below.

Detailed SOPs cover the following greenhouse activities:

[**Greenhouse Seeding**](#)

[**Greenhouse Vacuum Seeding**](#)

[**Greenhouse Potting Up**](#)

[**Greenhouse Hardening Off**](#)

Additional SOPs address the “how-tos” of specific UK-CSA protocols:

[**Row Covering and Netting**](#)

[**Field Fertigation**](#)

[**Tomato Tying**](#)

In addition, several SOPs discuss key management areas:

[**Greenhouse Management**](#)

[**Irrigation Management**](#)

[**Harvest Management**](#)

[**Packing Shed Management**](#)

[**High Tunnel and Solar Greenhouse Management**](#)

1. SOP: GREENHOUSE SEEDING

Review the checklist every time when working in the greenhouse.



Figure 1.1

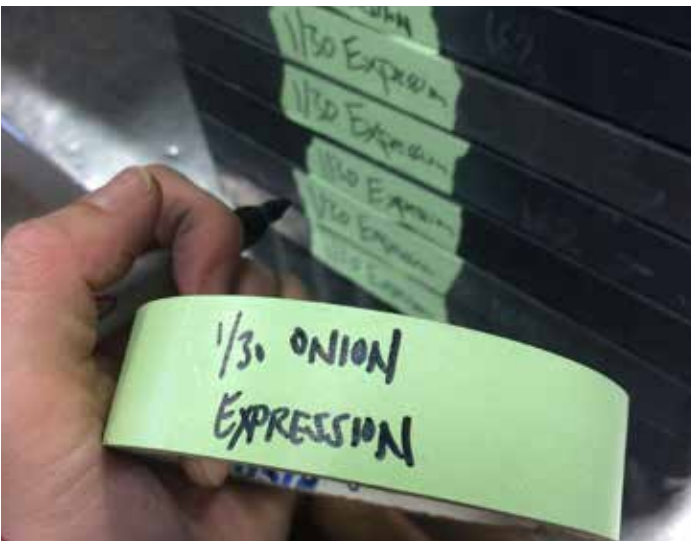


Figure 1.2

Table 1.1

Greenhouse Media Selection	
Germinating flats for herbs, flowers	ProMix
Turmeric, Ginger	ProMix
Select Cucurbits: Summer Squash, Winter Squash, Cantaloupe	ProMix
Microgreens, Shoots	ProMix
Everything else	Vermont Compost

- Before starting to seed crops into trays, gather supplies:
 - [Greenhouse Calendar](#)
 - Seeds from the seed storage location
 - Potting media and mixing bin
 - Greenhouse cart
 - Clean trays
 - Label maker or labeling tape and pencil or Sharpie marker
 - Vacuum seeder or hand-seeding tools
- Choose trays of the correct size from the clean stack in the greenhouse. Winstrip trays are labeled “ORG” for organic production and have the Winstrip number written on the side. There are four sizes of trays, from smallest to largest cell size: 162, 128, 72, and 50. Consult the [Greenhouse Calendar](#) to choose the correct tray size (Figure 1.1).
- Label all trays prior to filling them. The tape will stick better before hands get wet when mixing the media in the next step. Always label with the seeding date, the crop name, and the variety name. When crops are going into a mixed-use house, designate them with initials or an abbreviation (e.g., “CSA”). Printed labels are preferred. When writing labels by hand, do not use ink pens on the labels, as they fade quickly. Pencil is best, but a black Sharpie marker is also suitable. Place labels on the short end, where they will face out and can be easily seen when they sit on the benches inside the greenhouse (Figure 1.2).
- Fill the mixing bin with scoops of potting media. Reference the [Greenhouse Media Selection](#) table (Table 1.1). Fill mixing bin three-quarters full, so there is space to move the media around to mix it (Figure 1.3).



Figure 1.3

1. SOP: GREENHOUSE SEEDING



Figure 1.4



Figure 1.5



Figure 1.6

5. Moisten the media with clean water and thoroughly mix it in. Add a little bit of water at a time until the proper moisture is reached. This step is important to avoid the pitfalls of overly dry media; media not properly moistened will become hydrophobic and repel water (Figure 1.4).

To test for proper moisture, make a ball with the media. When this ball is dropped from about one foot above the mixing bin, it should readily fall apart on contact (Figure 1.5).

6. To fill trays, sit the tray inside the mixing bin and pile the media on top of the tray. The important part is to pack the media evenly into the trays without over compacting it. To achieve this, shake the trays by picking them up several inches and then dropping them down several times to settle the media. Pile on top a second layer of media, being sure to pay attention to the corners, which are the areas of the tray most likely to get filled unevenly. Once the tray is packed well, brush all excess media back into the mixing bin. Set the filled and smoothed tray aside until ready to dibble (Figure 1.6).
7. Select the dibbler that matches the Winstrip tray size. If seeding squash or melon, skip this step and go straight to Step 9.

Center dibbler on top of each tray and press down evenly to make indentations in the center of each cell (Figure 1.7).

8. If using the vacuum seeder, see [SOP: Greenhouse Vacuum Seeding](#).



Figure 1.7

1. SOP: GREENHOUSE SEEDING

9. If hand-seeding, select the appropriate seeding tool. If seeding squashes or melons, these seeds are easily dropped individually in the cells by hand. However, the best way to seed larger items is by setting them on top of a tray that is not dibbled and then pressing them down into the cell by hand. This pressure helps create a dibble at the desired depth and also functions to help secure the seed in the tray (Figure 1.8).

Be sure to only hold a small amount of seed in hand at a time to prevent extra seed from being contaminated with potting media or moisture.

When hand-seeding smaller items, tools like widders, scoop spatulas, micro spatulas, or hand sowers are helpful. A micro spatula can also be used to singularly drop seeds held in the scoop spatula (Figure 1.9).

10. Each cell should have one seed. Once the seeds have been deposited into each cell, the tray can be covered with another thin layer of potting media. Place the tray inside the mixing bin again and mound up a top layer of potting media. Lightly press down while smoothing out the surface, brushing the excess back into the bin. Since the tray was dibbled, no seeds should get moved around out of their cells.
11. Place completed trays on a greenhouse cart. Multiple trays can be stacked on one another at an offset. Once the cart is filled, transport trays to their destination and carefully unload, always using two hands. Make sure labels face out on the benches. Always water the trays immediately after placing them in the greenhouse. Be sure to extend the waterer past the edges of each bench for proper coverage (Figures 1.10 and 1.11).



Figure 1.9



Figure 1.10



Figure 1.8



Figure 1.11

1. SOP: GREENHOUSE SEEDING

Greenhouse Operations Clean-Up Checklist

- Do crops need to go on a heating mat? If so, was the heating mat set to the correct temperature?
- Do crops need to go under the misters in House 2?
- Were trays watered once they were placed on the greenhouse benches? Are crop labels facing outward?
- Was the [Greenhouse Calendar](#) completed with seeding date and seeded amounts?
- If seed is short or cannot be found, was the CSA manager notified?
- Was the work surface wiped down after use?
- Was the floor around the workstation swept? Was the hallway checked, to see if further sweeping was necessary?
- Were the greenhouse cart and dibbler trays sprayed off with water after use? Was the cart returned to the hallway?
- Was the floor squeegeed into the head house floor drain after spraying the cart?
- Was all seed stowed back in the appropriate labeled bins and labeled bags?
- Was the potting media mixing bin and cart stowed in the hallway?
- Were the CSA hand tools and [Greenhouse Calendar](#) returned to the ticket holder and hung in the greenhouse?

2. SOP: GREENHOUSE VACUUM SEEDING

A Berry Precision Seeder is used to vacuum seed several crops, including brassicas, leeks, pelleted lettuce, onions, and spinach.

1. After the trays are filled with potting media, use an appropriately sized dibbler to make indentations in each cell of the tray into which the vacuum seeder will deposit the seeds. Dibblers are metal trays with marbles glued in the pattern of the cells for each tray size (Figure 2.1).

The dibbler size should match the tray size. For example, on a tray containing 128 cells, each cell measures one-half inch squared. Size labels are written in permanent ink on the side lip of the dibbler (Figure 2.2).

2. Flip the dibbler upside down on top of the tray. Line up the four corners to ensure the dibbler is centered on top. Press down firmly and evenly across the entire backside of the dibbler until it sinks into the tray cells (Figure 2.3).
3. When the dibbler is removed, there will be indentations centered in each cell where the seeds will be deposited (Figure 2.4).
4. Rinse off the dibbler after use before stowing.
5. The Berry Precision Seeder is a polycarbonate box that uses a small vacuum with an attached hose to suction seeds to a seeder plate corresponding to the greenhouse tray. The seeder plates are interchangeable. Similar to the dibbler, each seeder plate is labeled on the outer edge to correspond with a specific tray size. If the seeder plate needs to be changed, begin by unscrewing the four screws located in the four corners of the seeder plate with a Phillips screwdriver (Figure 2.5)



Figure 2.3



Figure 2.4

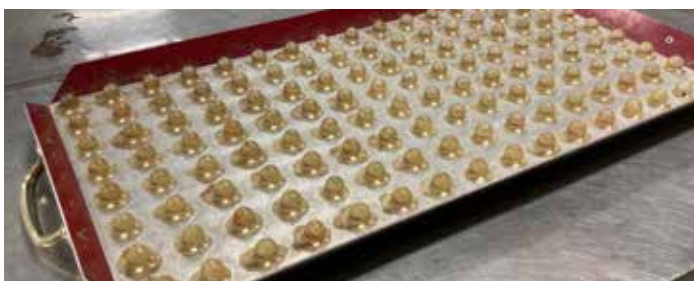


Figure 2.1



Figure 2.2



Figure 2.5

2. SOP: GREENHOUSE VACUUM SEEDING



Figure 2.6



Figure 2.7



Figure 2.8

6. Remove both the screw and rubber gaskets from the top, and the rubber feet holding the nut on the bottom of the polycarbonate box. These screws, gaskets, feet, and nuts should be set aside, as they will be reinserted to attach the new seeder plate (Figure 2.6).
7. Each seeder plate has rubber strips along the backside in the shape of the plexi box (Figure 2.7).

When placing the new seeder plate, line up all rubber strips with the top edges of the polycarbonate box. These strips are important for proper suction. If any strips are peeling or degraded, replace them with new adhesive-backed rubber strips. Be sure the seed channel along one of the long edges of the seeder plate is at the bottom, closest to the edge of the worktable.

8. Reinstall the screws, gaskets, rubber feet, and nuts in each of the four corners. Tighten with the Phillips screwdriver until snug. Hold the rubber feet in place at the bottom while tightening the screws from the top (Figure 2.8).
9. The vacuum seeder is powered by a simple, small vacuum or shop vac. There are two hose openings in the polycarbonate box, on the left and right sides. Insert the vacuum hose end into either side and push the lever out to the open position (Figure 2.9).

On the opposite side, push the lever in to close the hose opening. The levers control the suction, so for maximum suction, the hose end stays open and the opposite side is closed.



Figure 2.9

2. SOP: GREENHOUSE VACUUM SEEDING

10. When it is time to seed, pour some seed onto the surface of the vacuum seeder plate (Figure 2.10).
11. Turn the vacuum on and make sure the suction is working. If the seeds do not stay on the holes, there is inadequate suction. Adjust the levers, if necessary. If the levers are too loose and not staying in position, tighten the plastic screw on the side next to the lever with a flathead screwdriver (Figure 2.11).

Individual holes may need cleaning if they get potting media or other debris stuck in them. The orifice cleaner is a small handheld tool with metal rods of different diameters that can be inserted into holes to clear any obstructions (Figure 2.12).

12. Gently shake the vacuum seeder box from side to side to move the seeds around until each hole contains a single seed. If multiple seeds stick on the holes, lightly tap the back of the box against the worktable or manually dislodge the extra seeds from the holes (Figure 2.13).



Figure 2.12



Figure 2.10



Figure 2.11



Figure 2.13

2. SOP: GREENHOUSE VACUUM SEEDING

13. Gently tilt the box forward at a 45-degree angle. Any loose, extra seed will then roll down into the seed channel at the bottom of the seeder plate. This seed channel holds extra seed and keeps it from being lost (Figure 2.14).

Note: If the seed channel is overflowing, too much seed was dropped on the seeder plate in Step 10.

14. Now it is time to line the vacuum seeder up with the tray. Tilt the vacuum seeder perpendicular to the tray and slowly lower it facedown on top of the tray. There are two ledges on the seeder tray surface. These ledges should hold the edges of the tray snug so it does not slide around. Be sure the machine is settled over the tray edges. If the seeder can be pushed side to side at all, the seeder is not set properly (Figure 2.15 and 2.16).
15. Push the seeder forward on the tray until it hits the tray's edge. When no more movement is possible, it is snugly placed on top and should be perfectly aligned.
16. Next, the seed is dropped into the tray. Simply release the suction by closing the hose lever on the side with the vac-

uum and opening the lever on the opposite, empty side. Sometimes a residual suction will momentarily continue to hold the seed in place. Gently knock the polycarbonate bottom of the seeder, facing up, to ensure the suction seal is broken.

17. When lifting the vacuum seeder off the tray, always raise it from the top, the edge closest to oneself, upwards. This ensures the extra seed captured in the seed channel on the bottom stays in place.
18. Check the cells of the tray. Make sure the seeds have fallen into the dibbled areas. If a hole or two is missing a seed, quickly hand drop a seed into the empty cells. If the seed is not in the dibbled center, then it was not lined up properly. Finally, cover the seeds with potting media.
19. Once all of the trays of a certain crop variety have been vacuum seeded, tilt the vacuum seeder so that all the seeds fall into a corner of the seeder plate. Tap the extra seeds back into their seed container (Figure 2.17).



Figure 2.14



Figure 2.16



Figure 2.15



Figure 2.17

3. SOP: GREENHOUSE POTTING UP

“Potting up” or “Potting on” is the process of moving a plant from a smaller cell to a larger cell. This process is important for crops that benefit from being in the greenhouse for a longer period.

1. Potting up is only done with certain crops. Consult the **Greenhouse Potting-Up Selection** table for reference (Table 3.1).
2. Start by removing individual plant cells from the tray. If multiple plants occupy one cell, gently pull them apart, holding onto the leaves if possible and not the stems, to separate their roots. If there is only one plant in the cell, loosen the root. If the plant is not rootbound, then little root separation will be required.
3. Fill a new tray with potting media. Place a new label on the tray with the potting-up date.
4. Lay the plant and its roots on top of the new cell. Place a micro spatula or spoon spatula tool in the middle of the root zone. Use the tool to gently press the roots down into the cell. A second push may be necessary to get all the roots buried in the tray. All roots must be below the surface (Figure 3.1).
5. This process will get the plant in the cell, but it will leave a small indentation on the surface (Figure 3.2). When the tray has been completely filled, add potting media into the gaps created at the surface. Going row by row, drop in small handfuls of media. Press it down to help secure the plant and shake off any excess.



Figure 3.1

Table 3.1

Greenhouse Potting-Up Selection	
162 to 50 cell	Eggplant, Peppers, Tomatoes
128 to 72 cell	Celery, Leeks, Herbs, Flowers



Figure 3.2

Indentation at surface needs backfilling.

4. SOP: GREENHOUSE HARDENING OFF

Hardening off is the process of gradually acclimating crops from their greenhouse environment to the elements outdoors, prior to planting, in order to reduce transplant shock.



Figure 4.1

1. Prior to hardening off, check plants for proper root-ball development. The root should hold the potting media together so that the media does not separate from the plant roots (Figure 4.1).
2. Consult the **Hardening Off Minimum Air Temperatures** table for the scheduled crops (Table 4.1). If crops are hardened off too early, the small plants may suffer cold damage.
3. Hardening off is done gradually, so that seedlings become accustomed to strong sunlight, cool nights, and less frequent watering. The goal is to harden crops off over seven to 10 days.

On a mild day, start with two to three hours of sun in a sheltered location. Use a wagon or a cart to bring plants outside and then move them back inside when needed (Figure 4.2).

4. Protect seedlings from strong sun, wind, hard rain, and cool temperatures. A hardening off area bordered on two sides by greenhouses and other buildings provides a windbreak and some shading (Figure 4.3).

Table 4.1

Hardening Off Minimum Air Temperatures		
Hardy	40°F	Broccoli, Brussels Sprouts, Cabbage, Kohlrabi, Leeks, Onions, Parsley
Half-Hardy	45°F	Celery, Endive, Lettuce, Napa Cabbage
Tender	50°F	Squash, Pumpkin, Sweet Corn
Tender	60°F	Cantaloupe, Cucumber
Tender	65°F	Basil, Eggplant, Peppers, Tomatoes



Figure 4.2



Figure 4.3

4. SOP: GREENHOUSE HARDENING OFF

- Increase exposure to sunlight a few hours at a time and gradually reduce frequency of watering. Be mindful to not let the seedlings wilt. Avoid fertilizing.
- Consult the **Direct Seeding and Transplant Soil Temperature Recommendations** chart for the relative hardiness of various crops and recommended soil temperature prior to planting (Table 4.2).

Onions and brassicas are hardy and can take temperatures in the 40s. After they are well hardened off, light frosts will not hurt them. Warm-season crops such as eggplants, melons, and cucumber prefer warm nights, with temperatures of at least 60 degrees Fahrenheit. They cannot withstand below-freezing temperatures or frosts, even after hardening off.

- Gradually increase exposure to outdoor conditions over four to seven days until crops can stay outdoors in the sheltered hardening off area overnight.
- Keep an eye on the weather and the low temperature predictions for overnight. If temperatures below the crop's minimum air temperature are forecast, bring the plants indoors or cover them with a row cover for protection.

Row covers are also essential at the outset if hardening off crops that are susceptible to flea beetles, like eggplant. Trays of plants are covered directly on the hardening bench or wagon (Figure 4.4).

- When seedlings are ready to plant, use a little bit of fertilizer to get transplants growing again and avoid transplant shock. Be sure to water plants after planting (Figure 4.5).



Figure 4.4

Table 4.2

Direct Seeding and Transplant Soil Temperature Recommendations		
Plant BEFORE frost free date	Soil temp 45°F or above	Beets, Broccoli, Carrots, Lettuce, Onions, Peas, Spinach, Turnips
	Soil temp 50°F or above	Cabbage, Cauliflower, Leeks, Radish, Swiss Chard
Plant AFTER danger of frost	Soil temp 60°F or above	Beans
	Soil temp 65°F or above	Untreated Corn seed
	Soil temp 70°F or above	Cucumbers, Melons, Okra, Pumpkins, Squash, Watermelons



Figure 4.5

5. SOP: ROW COVERING AND NETTING

Row covers are used for thermal buffering, wind protection, and pest exclusion. Netting is only used for pest exclusion.



Figure 5.1

1. Two people work together to install hoops, with one walking on each side of the bed. One person holds a stack of hoops and installs one end of each hoop in the soil on one side, while the second person helps to grab the other hoop end and push it into the soil on the opposite side. (Figure 5.1).
2. Single hoops should be spaced apart every five feet in row. Hoops can also be doubled up and used in a crisscross fashion. This provides more stability and may allow for greater spacing between the sections, but it will require more hoops. At UK-CSA, we start and end every bed with two crisscrossed hoops.

If hooping and covering multiple beds side by side, stagger the hoop spacing in the adjacent beds for greater stability with larger covers.

3. Using two to three people, have one person drive the forklift carrying the pallet of pavers in the drive row next to the field. The second worker wears work gloves and unloads the pavers from the pallet as the forklift moves down the row. They drop one paver every four to five feet and toss a paver to the other side, or to the third person, standing inside the field closest to the beds to be covered (Figure 5.2).

Tip: By moving the forklift backwards down the drive row, workers can always face the driver, and danger of moving in the path of the tractor is minimized.

4. Once the pavers are dropped, the row cover can be pulled out the length of the bed. If the row cover is in a macro bin, this can also be carried by a forklift and driven alongside the field. The workers can pull the cover or netting out of the macro bin. If the netting is daisy chained, it should also be unchained at this step and pulled down the length of the field (Figure 5.3).



Figure 5.2



Figure 5.3

5. SOP: ROW COVERING & NETTING



Figure 5.4



Figure 5.5

5. Pull the cover over the crops until it is loosely hanging across the entire section to be covered (Figure 5.4).
6. Covering is best done with four people who work in pairs. Each pair works on one side of the bed being covered. The key is for the pairs to work together and not get ahead of one another.

Each pair will have one person as the netting positioner and one person as the paver placer. The positioner stays in front of the paver placer. The positioner's job is to pull the net firmly to the ground and away from the placer by gently tugging the cover or net at the bottom edge. The partner then sets the paver on top of the cover or net edge. It is placed close to the hoop and on the net fully, if possible, for maximum hold (Figure 5.5).

Roll or fold any excess on the edges in on itself, until the net is tight across the hoops (Figure 5.6).

Once the paver is placed, both workers move down five feet to the next paver and repeat the action. Pairs on each side of the netted area should stay close to one another, so that the cover or net stays smooth and tight against the top of the hoops. If there is excessive slack, the covers will ripple in the wind. This is a sign that the cover is not pulled down tightly enough.

7. Once the long sides have been weighted, be sure the two ends are also closed off and weighted to finish.



Figure 5.6

6. SOP: FIELD FERTIGATION

Only crops reaching maturity beyond 56 days are fertigated.

1. To prepare for fertigation, first weigh out the calculated amount of Allganic Nitrogen Plus 15-0-2 into a clean, empty five-gallon bucket. (Figure 6.1).
2. Use a broom handle or stick to mix water into the fertilizer bucket to create a slurry (Figure 6.2).
Pour slurry into tank of fertigation injector.
3. Add approximately 10-15 gallons of additional water to the tank in order to increase the quantity of water and extend the time of fertigation (Figure 6.3).
4. After the irrigation water has run in the field for about two-thirds of the entire time desired to irrigate, begin fertigation. Drive the fertigation injector, connected to the ATV, out to the field (Figure 6.4).
5. Halt irrigation supply to the field to be fertigated by turning off the ball valve on the header manifold. Remove the header coupler from the manifold and insert the fertigator tee.



Figure 6.2



Figure 6.3



Figure 6.1



Figure 6.4

6. SOP: FIELD FERTIGATION

- Once the fertigator tee is inserted next to the start of the header line, turn the ball valve on the header manifold back to the open position. The ball valve may need to be partially closed to reduce water flow for the fertigation pump to inject properly. (Figure 6.5).
- Turn the fertigator switch to “on” and open up the valves on the pump (Figure 6.6).
- If there is too much pressure, the tank will not decrease. If the tank is being emptied rapidly, partially close the water valve to slow down the rate of injection. Ideal pump pressure is around 15 psi, which is more than the drip line pressure of 12 psi to ensure proper injection. Check to make sure the tank is steadily decreasing (Figure 6.7).
- Shut off the pump switch before the tank empties entirely to avoid the need to prime the pump on the next fertigation. A gurgling noise will be the cue to stop. A small amount of water will still be in the tank.
- After completing fertigation, turn the manifold off again to remove the fertigation tee. Resume irrigating the field to flush the lines with clean water and complete the final third of the desired irrigation duration (Figure 6.8).



Figure 6.6



Figure 6.7



Figure 6.5



Figure 6.8

7. SOP: TOMATO TYING



Figure 7.1

1. Start with a box of Gro-Tie twine attached to one's belt. If a worker is not wearing a belt, a scrap of drip irrigation line can be used as a belt to hold the box at one's waist (Figure 7.1).

Run the end of the twine through two holes drilled into opposite ends of a wooden handle or broomstick. The twine is pulled through the first hole at the top of the handle, and then pulled down the length of the handle and pushed through the second exit hole at the bottom of the handle. Pull one to two feet of twine out from the bottom hole.

2. Secure the twine to the bottom of the first T-post with a simple overhand knot, about four inches above the bed top. Each additional tie starts about four to five inches above the preceding one (Figure 7.2).

Next, the worker begins the Florida weave. The Florida weave is a figure-eight pattern of tying tomatoes. Each worker will walk the entire tomato bed in two passes.

Note: The photos show the second pass, which completes the figure eight.

3. During the first pass, the worker uses the broomstick to run the twine on the back side, outside of the first tomato plant (Figure 7.3).



Figure 7.2



Figure 7.3

7. SOP: TOMATO TYING

4. The worker then pulls the twine across the middle and to the front of the second tomato plant (Figure 7.4).
5. Circle the broomstick around the second T-post, lifting the twine by hand over the top of the post (Figure 7.5).

The twine should make an S pattern around the two tomato plants. The twine should be kept taut at all times.

6. On the next section, the pattern is mirrored. The twine comes off the front side of the second T-post and will stay in front of the third tomato plant (Figure 7.6).

Pull the twine across the middle, and around the back side of the fourth tomato plant. Circle the third T-post once. From there, a mirrored S pattern is created around the next two tomato plants.



Figure 7.5



Figure 7.4



Figure 7.6

7. SOP: TOMATO TYING

7. Repeat this process until the end of the row is reached. At the end of the row, wrap the twine several times around the end T-post.
8. The worker now walks around the bed to the other side and completes the second pass in the opposite direction. Following the same pattern, the twine will now make a complementary S pattern around each set of two tomato plants to complete the figure-eight design.
9. At the completion of each figure eight, there should be one tomato plant held by twine on front and on back, which represents the top of the figure eight, and the second tomato plant should likewise be held by twine on front and on back for the bottom of the figure eight. Each plant should be contained in its own pocket, and the crossover in the middle should keep each plant from touching another. In addition, the height of the twine should be level along the length of the row. There should be no vertical gaps of space between the two twine passes (Figure 7.7).
10. If the twine did not capture the plant in the first attempt, workers should bend down to fix plants or have a helper go back through and situate plants in between the twine. It is better to keep the twine taut on the first passes and fix plants afterward rather than leave the string too loose at the start.

Note: If the T-posts are not installed in-row with the plants, the twine will not capture the plants and more tucking will be required (Figure 7.8).

11. Each half-bed is ended with several wraps around the last T-post. The twine is knotted, and then the end is cut with a pocketknife.
12. Additional ties are made weekly, so each row of indeterminate tomatoes may be tied five or six times in a season, based on plant height.

The ties after the initial strand omit the crossover to make the figure eight. Instead, twine is carried only on the front and back side of plants from T-post to T-post, sandwiching both plants in a pocket of twine. Twine is wrapped around each T-post once before running the next line. All lines of twine are kept level as before, spaced four to five inches above the prior tie.

To view videos of the Florida weave technique, click on the following links:

[Video 1: Florida weave](#)

[Video 2: Florida weave](#)



Figure 7.7



Figure 7.8

8. SOP: GREENHOUSE MANAGEMENT

The greenhouse manager monitors and stays aware of the activities of the greenhouse, including seeding, potting up, fertigating, scouting, hardening/moving plants around if needed, and in general, making sure transplants are ready for transplanting.

Schedule

The greenhouse manager's tasks should be completed at least once during the week, but may be necessary every day of the week, or at least two or three days per week, at peak times.

Scouting

The greenhouse manager inspects UK-CSA plants held inside the certified organic (ORG) houses: ORG House 2 and ORG CSA House. Scouting activities include the following responsibilities:

- Checking plants for poor germination
- Checking trays for doubling in cells and thinning
- Inspecting for insect issues (e.g., aphids, fungus gnats, white flies, and flea beetles)
- Inspecting for fungal issues (e.g., damping off)
- Checking for plants ready to be hardened off
- Checking for signs of plants in need of fertigation (e.g., age, yellowing, and size)
- Checking seeding schedule for the current week's seeding needs
- Checking for potting-up readiness
- Checking for old plants and trays to be cleaned out
- Checking inventories (e.g., clean trays, potting media, seeds, and fertilizer). Inventory checks are made in December/January in preparation for the next year and monthly, or as needed during seeding. Any material shortages are reported to the CSA manager.

Germination

Count seedlings in trays and compare to number needed for field on the [Greenhouse Calendar](#). Seed more as soon as possible, if necessary.

Thinning

If there is more than one plant per cell, additional plants are pinched off as early as possible. If cell germination is spotty or uneven, any additional plants in a single cell are pulled out and moved to an empty cell.

Insect Issues

Look under leaves and at the growth points for insect pests. Some insects can be excluded (e.g., flea beetles) by using row covers over susceptible crops, such as eggplant, when they are moved outside.

Depending on how heavy the infestation appears, insects are picked off or sprayed off with a stream of water, or the plants are treated with a pesticide, using an atomist electric sprayer.

Fungal Issues

Damping off often occurs due to overwatering. Watering is done by the facilities manager or arranged by the farm superintendent on holidays and weekends. Plants of different sizes have different watering requirements. If the whole tray has uneven germination, this will cause some cells to dry out quicker and others to stay moist for longer.

If plants appear slow growing or stunted, pull plugs out of the trays and inspect the roots. Lack of proper root development is also evidence of fungal issues. Reseeding may be necessary if substantial fungal issues are present. Note the crop and variety that is incurring fungal problems and notify the CSA manager.

Hardening Off

The [Greenhouse Calendar](#) includes a hardening-off schedule. Check plants for good root-ball development as an indicator of plant readiness. Hardening off of plants prepares sheltered seedlings for being in an open, uncontrolled environment. See [SOP: Hardening Off Crops](#) for more information.

Fertigation

Most plants do not need to be fertigated often. For the amount of time that most plants are in the trays, there is enough fertility in the potting media, and no additional fertility is needed until the time of transplanting.

Most plants grown in media with added fertilizer or in compost-based media will require fertigation or potting up with new media four to six weeks after emergence. Any weekly fertigation events are stopped one week before hardening off. Final fertigation is done immediately before planting. Daily rate is 15-30 ppm of nitrogen. The weekly rate is 200-300 ppm of nitrogen. Basil can be used as an indicator crop for fertigation needs, as it shows nitrogen deficiencies clearly.

Seeding

Check the [Greenhouse Calendar](#) for the list of crops that need to be seeded that week. Make sure the CSA manager is

8. SOP: GREENHOUSE MANAGEMENT

aware of what needs to be done that week, so that it gets put on the task list. Take note of how many trays will need to be seeded so the appropriate number of people are assigned to the job. If it is less than 10 to 12 trays, only one person is needed. Group all weekly greenhouse seedings together on the same day to save on time required for set up and clean up. See [SOP: Greenhouse Seeding](#), [SOP: Greenhouse Vacuum Seeding](#) for more information.

Potting Up

The potting-up dates are estimated on the Greenhouse Calendar. Make sure there are enough clean trays for the task and that crops are potted up in a timely manner. See [SOP: Greenhouse Potting Up](#) for more information.

Cleaning

After transplanting, the leftover crops are brought back to the hardening-off benches behind the greenhouse to be watered. Typically, these plants are held onto for at least one week for possible use as replanting stock where field transplants may have died from transplant shock. After one week, the plants are composted. Remove the labels from the trays and bring the empty, dirty trays to the packing shed for washing on the rinse conveyor. Dirty trays that were taken to the field should not be brought back to the greenhouse until cleaned, as they pose a pathogen risk.

In the case of some transplants that are sold, the plants are held onto longer in order to be sold at future farm stands. These crops include flowers, herbs, tomatoes, and peppers.

Inventory

Be aware of inventory when seeding and checking on crops. If fertilizer or potting media (PRO-MIX or Vermont Compost) becomes low, notify the CSA manager.

Other Notes

Heat mats are available for general use. Check with the facilities manager for their availability. Crops that benefit from heat mats include peppers (80°F), early tomatoes (75°F), and some flowers (70°F to 85°F, depending on variety). Once a tray reaches 75-80 percent germination, it should be removed from the heat mat.

Crops that belong under misters include herbs and flowers for germination and any brassica or lettuce crops seeded in June or July during the heat of summer for cooling. Check with the facilities manager for space under the misters in House 2 and any adjustments needed for misting intervals, if the trays are getting inadequate or excessive watering.

As plants grow, some will grow taller and faster than others. If a slower-growing, smaller plant is placed next to a faster-growing, bigger plant, the bigger plant will shade or crowd the smaller one out. If an entire tray of smaller plants is set next to larger plants, the entire tray may suffer from inadequate watering as well. Move the smaller tray where the larger plants cannot overshadow it.

Similarly, keep newly seeded trays grouped together so older plants do not interfere.

When plants get larger, keep some space in between the trays so transplants do not get intertwined. Spaces between trays will make watering coverage more even and allow for the best possible airflow to decrease chances of disease.

Place trays strategically on the greenhouse benches. All trays are first placed on the same side of the house, and when a full side bench is filled, newly seeded plants will be moved to the next bench. Grouping trays together helps the waterer to work efficiently and maintain even watering.

9. SOP: IRRIGATION MANAGEMENT

Irrigation is managed to ensure that crops get the proper amounts of water at the right time to reduce crop stress and optimize crop yield. The soil type at UK-CSA is a Maury silt loam. This soil has a water-holding capacity of 2.5 inches per foot, or 0.2 inches of water per inch of soil¹. The drip tape used is Toro Aqua-Traxx Premium drip tape, 8 mil thickness, with six-inch emitter spacing. It has a flow rate of 0.67 gallons per minute (GPM) at 8 psi, or 0.82 GPM at 12 psi².

In order to provide crops with a base level of one inch of water a week, it will require 3.8 hours of irrigation per bed with one drip line per bed or two hours with two drip lines per bed at 0.82 GPM. Rainfall and evapotranspiration (ET) must also be factored in for day-to-day irrigation management.

While many crops can withstand 40-60 percent soil moisture depletion before irrigation, some crops are more sensi-

tive and can only withstand 20-25 percent depletion. Sensitive crops include celery, onions, peppers, spinach, and strawberries³. Therefore, the maximum management allowed depletion (MAD) of moisture before an irrigation event is 20 percent when all crops are managed on the same irrigation schedule. For silt loam soils, this is 0.5 inches of the maximum 2.5-inch water-holding capacity lost. When using a soil moisture tension sensor, like Irrrometer Watermark sensors or Irrrometer SR tensiometers, the 20 percent MAD occurs at 36 centibars for loams⁴. Any value higher than 36 centibars is the threshold for irrigation.

Irrigation Event Scheduling and Duration

To determine the next irrigation event, several steps are necessary:

1. Consult the evapotranspiration rates at [http://www-ag-wx.ca.uky.edu/ky/agmodels.php](http://www.ag-wx.ca.uky.edu/ky/agmodels.php). Click on “Irrigation Manager” on the left side bar and select your county and dates to find the calculated reference evapotranspiration value (ET_o).
2. Multiply the ET_o reference value online by the crop coefficient (K_c) in Table 9.1 to get the specific crop evapotranspiration amount (ET_c). Several ET_c values may be added for a weekly total.
3. Subtract the total ET_c value from a field capacity of 2.5 inches.
4. Add back the value for rainfall accumulation for the week for bare-ground beds, but only add rainfall accumulation in excess of one inch for plasticulture beds.
5. The result is the plant available water (PAW) amount for that week.
 - Values above 2.5 inches indicate no irrigation is necessary, as the field is at capacity.
 - Values below 2.5 inches indicate moisture depletion. When the value dips below two inches, this is 20 percent or more depletion, and irrigation should be initiated.
6. Determine duration of irrigation event based on water requirements, pressure, and number of drip lines per bed using Table 9.2.
7. If the initial field capacity is unknown, use Watermark sensors or tensiometers installed at depths of six to 12 inches to establish reference points (Figures 9.1 and 9.2). The Watermark sensors will provide values in kPa or centibars; 36 centibars for loamy soils indicates 80 percent AW, which is the 20 percent depletion threshold. If the centibar reading is 36, then soils need 0.5 inches of water to regain field capacity of 2.5 inches.



Figure 9.1 Tensiometer.



Figure 9.2 Watermark sensors.

9. SOP: IRRIGATION MANAGEMENT

Table 9.1 Crop coefficients⁵.

<i>Crop</i>	<i>Kc Initial Growth</i>	<i>Kc Middle Growth</i>	<i>Kc Ending Growth</i>
Beans	0.5	1.05	0.9
Beets	0.5	1.05	0.95
Broccoli	0.7	1.05	0.95
Cabbage	0.7	1.05	0.95
Carrots	0.7	1.05	0.95
Cauliflower	0.7	1.05	0.95
Celery	0.7	1.05	0.95
Corn	0.3	1.15	0.4
Cucumber	0.6	1	0.75
Green Onions	0.7	1.05	0.95
Lettuce	0.7	1	0.95
Onions	0.7	1.05	0.95
Peas	0.5	1.15	1.1
Peppers	0.7	1.05	0.85
Potato	0.5	1.15	0.75
Pumpkin	0.5	1	0.8
Raspberries	0.4	1.2	0.75
Spinach	0.7	1.05	0.95
Squash	0.5	0.95	0.75
Strawberries	0.4	1.05	0.7
Sweet Corn	0.3	1.15	0.4
Sweet Potato	0.5	1.05	0.95
Tomato	0.7	1.05	0.8
Watermelon	0.4	1	0.75

Kc = Crop Coefficient

Duration of each irrigation event depends not only on the plant available water (PAW) but also on psi of the water source, number of drip lines per bed, and maximum number of drip lines that can be supplying irrigation water without a decrease in source pressure. At the UK-CSA system, plastic beds have a single line of drip tape, while bare-ground beds have double lines of drip tape. The psi of individual drip lines can be checked by connecting a pressure gauge to the

Table 9.2 Irrigation rates.

One line of drip tape per bed		Two lines of drip tape per bed	
PSI	Rate (inches water/hour)	PSI	Rate (inches water/hour)
4	0.13	4	0.26
5	0.14	5	0.29
6	0.16	6	0.32
7	0.17	7	0.34
8	0.18	8	0.37
9	0.19	9	0.39
10	0.2	10	0.41
11	0.21	11	0.43
12	0.22	12	0.45
13	0.23	13	0.46
14	0.24	14	0.48
15	0.25	15	0.5

Example: Newly transplanted broccoli plants are irrigated to reach field capacity at time of planting. That week there is a slight rainfall of 0.08 inches. The ET for the past seven days totals 0.91.

Broccoli crop coefficient (Kc) for initial growth is 0.7, therefore $0.91 \times 0.7 = 0.64$ ET.

*The field capacity of 2.5 inches - 0.64 ET = 1.86 inches
1.86 inches + 0.08 inches rainfall = 1.94 inches*

Since 0.56 inches of water lost is greater than the 0.5-inch MAD threshold, irrigation is initiated. With field lines at 12 PSI, 0.45 inches of water is applied in one hour on bare-ground, double drip tape beds. Therefore, one hour and 15 minutes of irrigation is required for broccoli.

end of the drip tape line in the field furthest from the header manifold, once the lines have been filled and have good turgor pressure.

Be sure that the scheduled irrigation event does not exceed the soil's capacity to absorb it. For a silt loam, the infiltration rate is 0.25 to 0.40 inches of water per hour⁶. As a result, shorter irrigation events may be needed to reduce water loss.

9. SOP: IRRIGATION MANAGEMENT

At UK-CSA, the main hydrant, after going through a pressure reducer to 35 psi, outputs 78 GPM. With drip tape capable of 0.82 GPM at a maximum of 12 psi, this allows for 9,512 feet of drip tape to be used to maintain pressure, or 31 total 300-foot drip lines in the main fields at one time. Given friction loss and reduction to 50 GPM through two-inch supply lines, 6,097 feet of drip tape, or 20 lines 300 feet long, is a more accurate estimated capacity without significant drop in pressure.

Drip tape is 85 to 95 percent efficient above ground and 95 percent or more efficient subsurface⁷. Therefore, the irrigation rates in Table 9.2 have compensated for this loss of application efficiency, using the lower level of efficiency of 0.85 for an adequate buffer amount. For more than two lines of drip tape on a bed, simply add onto the two drip-line rate the rate for one drip line for each additional line used.

Irrigation Protocols Modified for Specific Circumstances

- Irrigation should occur immediately after direct seeding. Irrigate to apply at least 0.5 to 0.75 inches of water at time of seeding, regardless of field capacity. With subsurface drip lines, it is ideal to irrigate until the wetting pattern is visible on the surface of the soil, which may take more than a 0.75-inch application for water to reach the soil surface.
- If temperatures are cooler than the optimal seeded crop germination range, irrigate for a minimum of 0.75 inches to one inch instead, to keep the soil moist^{8,9}.
- After this initial soaking, lower rates of irrigation of 0.2 to 0.3 inches at more frequent intervals help to maintain moisture on the soil surface, prevent drying out and crusting, and hasten seedling emergence. Once seeds germinate, follow normal protocols.
- Some crops will require drip tape to be laid on top of the bed to prevent soil surface crusting. Carrots in particular are irrigated on top of the bed if no rainfall is in the forecast, or seeding timing should be adjusted in order to take advantage of a forecasted rain.
- Irrigate immediately after transplanting. Irrigate to apply at least 0.5 to 0.75 inches at time of transplanting⁸.
- Irrigate after plastic mulch installation for setting up the wetting boundaries in preparation for planting. The initial plastic mulch bed irrigation should be seven to 10 days prior to transplanting into the bed.
- Increasing the MAD threshold for irrigation (thereby reducing overall irrigation) during early vegetative growth may aid in deeper root development and reduce leaching risk¹¹.

Field Checks

- Fields and lines need to be checked during the first irrigation to ensure proper functioning and pressure. After confirming proper supply at setup, they should be checked intermittently for the rest of the season. Occasionally, mechanical or animal tears occur in the lines, which are repaired with drip tape loc couplings, or “splicers.” Team members who hear or see a leak should fix it, if possible, or alert the irrigation manager.
- Field moisture may be checked by feel using a soil probe at six-inch and 12-inch depths. Silt loam soils will form a ball readily and feel slick on the skin, adhering to one’s fingers slightly when under pressure at 50 to 75 percent PAW, and at field capacity, the soil will form a ball easily and will ribbon readily to a one-inch length without breaking when pressure is applied to the soil to push it between thumb and forefinger. Learning the feel of the soil at different water capacities is an effective check on irrigation management decisions.

Tools for Irrigation Management

Irrigation management involves a suite of tools and materials for setup, maintenance, and troubleshooting (Figure 9.3). A five-gallon bucket outfitted with a bucket organizer can hold most of the necessary items:

- Channellock pliers to aid in turning water on or off if ball valves break or are broken
- Punch tool for installing new emitters in header lines
- Drip tape mini valve oftakes, or “emitters,” for replacing broken ones
- Splicers for fixing leaks
- Utility knife for making straight cuts on layflat
- Hose clamps for tightening seal of layflat
- Nut driver for tightening hose clamps
- Male and female 1.5-inch and two-inch couplers for replacing any header or supply line connections
- Barbed straight couplings, both 1.5 inches and two inches in diameter, for repairing any supply- or header-line tears
- Scrap drip tape for capping ends of lines
- Pressure gauge to check end of drip lines
- Tubing for adjusting alignment of header-line emitter holes with the beds
- Watermark sensor meter for checking soil moisture tension (Figure 9.4)
- Soil probe for testing soil at six-inch and 12-inch depths by feel (Figure 9.5)

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Figure 9.3 Irrigation supplies and tools.



Figure 9.4 Watermark sensor meter.



Figure 9.5 Soil probe.

10. SOP: HARVEST MANAGEMENT



Figure 10.1 Portable hand-washing station is loaded on the wagon for washing hands in the field.



Figure 10.2 Harvest tote.

The harvest manager is tasked with determining crop readiness for harvest; training and overseeing staff on correct harvest procedures for each crop; keeping crops moving to the pack shed for post-harvest handling; and dividing the workforce efficiently between tasks.

Food Safety Protocols

Be sure all workers wash hands with soap and water prior to harvest. Workers are responsible for choosing the most appropriate harvest clothing (e.g., boots, raingear, hats, or sunglasses) in advance, and they are also responsible for bringing their own water bottles to the field. Long sleeves are recommended for squash harvest, and gloves are recommended for harvesting tomatoes and sweet potatoes.

Materials

The harvest manager ensures all the necessary supplies are loaded on the harvest wagon and brought to the field with the workers. Materials to bring include the following items:

- Harvest Log and pens
- Row-feet wheel
- Scale
- Harvest bins, and one extra bin per worker for use as in-field “drag bin”
- Macro bins, if needed
- Portable hand-washing station with filled water dispenser, soap, and paper towels (Figure 10.1)
- Extra nitrile gloves
- Tote with sanitized tools, as shown in Figures 10.2 and 10.3, and knife sheaths (e.g., lettuce field knives, serrated knives, pruners, loppers, hedge shears, and tobacco knives)
- Rubber bands (small or large) or twist ties, and waist aprons to hold bands
- Bicycle for bathroom breaks
- Quick-cut Greens Harvester, drill, and charged drill batteries (for direct-seeded greens)



Figure 10.3 Harvest tools.

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All tools are sharpened with the Work Sharp tool-and-knife sharpener and then sanitized with a 10 percent bleach solution prior to use.

Field Setup

Depending on the crop, either the harvest wagon or harvest conveyor will be used and taken to the field (Figures 10.4 and 10.5). If using the harvest conveyor, it must be connected to a tractor with hydraulics (Kubota 5030 or Kubota 9540). If using the harvest wagon, it can be connected to a truck with a hitch drawbar or a tractor with a hitch drawbar.

Crops that are best harvested with the conveyor include broccoli, cabbage, cauliflower, melons, and winter squash. Some crops, including peppers, summer squash, and zucchini, can use the conveyor for picking up bins.



Figure 10.4 and 10.5 Harvest wagon, at the top. Harvest conveyor, hooked up at bottom.

Green beans are always harvested with the Pixall BH100 Bean Harvester, and potatoes are harvested using the potato digger. In addition to these machines, a truck should always accompany the bean harvester to hold bins, and the harvest wagon should be taken to the field with the potato digger, staged with two macro bins (Figure 10.6).

Crops that require use of macro bins include brussels sprout stalks, cabbage heads, cantaloupes, potatoes, pumpkins, sweet potatoes, watermelons, and winter squashes. Two macro bins can fit on the conveyor wagon, situated on either side of the conveyor's front. Up to three macro bins can fit on the harvest wagon. Two of the bins should be set up over the front and rear axles, which provide support. A third bin, if needed, can fit in the middle. Always position bins flush with the outer edges for ease in removing them with forklifts at the end of the harvest.

The harvest wagon is driven to the field by truck or tractor. Always connect a tractor when drive-row conditions are wet. Enter the field drive row from either the north or the south. If harvesting greens, bunched items, or root vegetables, park in the middle of the field. This will help harvesters to bring their full bins to the shade with less walking from either end of the field. If harvesting with buckets for crops like sweet corn, summer squash, peppers, eggplant, or cucumbers, then park at the first end that is pulled into. The wagon will traverse the length of the field at the end of the harvest to pick up bins down the row.



Figure 10.6 Macro bin.

10. SOP: HARVEST MANAGEMENT

Empty harvest bins are dropped along the length of the drive row for easy grabbing by the crew when needed (Figure 10.7). Empty bins are dropped for broccoli (when not using conveyor), potatoes, sweet corn, and sweet potatoes.

Harvest Order

Crops are harvested in order from those most affected by water loss to those least affected¹². The exception is sweet corn, which is always harvested first, in the cool morning, to minimize conversion of sugar to starch. See Table 10.1.

Harvest Training

Workers are instructed in proper harvest technique. Refer to individual crop profiles in the [CSA Crop Handbook](#). Harvest training covers the following elements:

- Technique, including which tools to use, how to use the tools, and knife safety
- Quality, including how to determine crop readiness, sort items, or cull low-quality produce
- Food safety, including scouting for bird droppings or other animal feces in the field or in contact with the cash crop
- Cleaning, including which crops need to be cleaned during harvest and how to clean them
- Bin use, with guidance on moving bins to shade or field edges, keeping a drag bin at all times, and how full to fill bins before starting new ones



Figure 10.7 Red harvest buckets dropped along drive row.

- Benchmarks, including expectations for how long it should take to harvest

The harvest manager divides the crew by task. Certain crops will be harvested by all (e.g., lettuce greens), while other crops will require designated teams for harvesting,

Table 10.1 Vegetable Crop Harvest Order.

<i>Harvest Order</i>	
1	Sweet corn
2	Spinach and leafy greens
3	Lettuce
4	Carrots with tops
5	Broccoli
6	Beets, turnips, radishes with tops
7	Cucumbers
8	Beans
9	Cabbages
10	Tomatoes
11	Leeks
12	Beets, carrots, turnips, radish roots only
13	Cauliflower
14	Potatoes
15	Peppers
16	Brussels sprouts
17	Celery
18	Onions
19	Winter squash
20	Summer squash
21	All remaining

Based on maximum permissible water loss, least to greatest.

Source: <http://www.postharvest.org/Water%20relations%20PEF%20white%20paper%20FINAL%20MAY%202015.pdf>

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teams for cleaning, and teams for bunching (e.g., beet and turnip bunches).

When harvesting an entire bed (e.g., lettuce mix), teams of two can be sent to different sections of the bed (Figure 10.8). Each person will work a single row, facing one another and moving in the same direction toward the center of the field. When harvesting an entire field (e.g., summer squash or peppers), workers should always start in pairs from the same end of the field, with all moving in the same direction. Each person in a pair works on either side of a bed. When harvest is selective (e.g., beets or turnips), the harvest crew is divided into different roles. Harvesters will all move in the same direction when harvesting across multiple beds. Cleaners will follow in the path of the harvesters.

When bins are full, they are carried to the outer edges of the fields to be picked up in the drive row with the harvest wagon. When it is sunny, crops are carefully placed in the shade underneath or beside the wagon (Figure 10.9), or empty bins are stacked on top of the full bins to provide cover. Crops do not sit outside in the heat of summer for more than an hour to limit desiccation. When harvest takes longer than one hour, the wagon is loaded up and crops are taken inside the packing shed to be set in shade, hydrocooled, or stored in the walk-in cooler until they can be washed.

During harvest, the harvest manager checks the crew's work for correctness, consistency, and quality.

Recordkeeping

Notes are made on the number of row feet harvested for each crop. One full bed of double-row crops is 600 feet, whereas a full bed of a single-row crop is only 300 feet. Other notes are made regarding crop readiness, timing, or any issues observed in the specific field or planting (Figure 10.10).

Tomatoes are weighed at time of harvest, and weights are recorded by harvest date as well as by type of tomato: hybrid, heirloom, or paste. Bins are labeled with weight and tomato type.

Other Notes

The harvest manager is responsible for keeping track of the number of bins being filled, communicating with the pack shed manager about bin needs, and ensuring the filled bins are moved to the shade or the pack shed in a timely manner. Crops should not be sitting outside for longer than an hour in the heat of summer.

When there are more than eight harvesters in the field, two teams can be formed and split up between two crops. A second team leader is designated to manage the harvest of the second crop.



Figure 10.8 Paired harvesters.



Figure 10.9 On sunny days, bins are carried to the harvest wagon and placed underneath in the shade.



Figure 10.10 Recordkeeping.

11. SOP: PACKING SHED MANAGEMENT

The packing shed manager moves the harvested crops through the process of washing, sorting, storing, packing, and tabulating harvest totals and CSA share amounts.

Food Safety Protocols

Be sure all workers wash hands with soap and water prior to working with harvested crops in the packing shed. Water bottles are allowed in the shed, but no other food or drink is permitted.

Packing Shed Setup

All surfaces in the shed are cleaned and sanitized before use. Surfaces are sprayed with a water hose, scrubbed with brushes if needed, and squeegeed off. A handheld spray bottle filled with a 10 percent bleach solution is used to spray all cleaned surfaces for sanitization. The surfaces are left to air dry. The following surfaces should be cleaned:

- Roller conveyor
- All stainless steel tables
- Sorting table shared by the brush and barrel washers
- Brush washer belt
- Salad spinner lids and interior baskets
- Dunk tank edges

Check the cooler and reorganize if needed. Consolidate bins, remove empty bins from the cooler, remove any crops from the previous week to the northeast side of the cooler door for GleanKY to pick up, and reserve crops as needed for staff use. Any puddles of water should be mopped, and the custom fork hand truck should be used to move stacks of crops around to make more room. If workers will be bringing in macro bins, the path into the cooler is cleared, and a spot large enough to drop the bins is also cleared.

Next, each of the needed wash stations are set up. Compost bins are placed at the wash stations for workers to use. UK-CSA uses five wash stations:

1. Dunk tank and bubbler
2. Rinse conveyor
3. Barrel washer
4. Brush washer
5. Bunched washing station (outside)

Preparing and Using the Wash Stations

All of the wash stations run off a single hydrant along the south wall of the packing shed. The water pressure is insufficient to support the use of more than one wash station at a time. It is best to fill 1) the dunk tank, and then 2) the rinse conveyor reservoir. Once these tanks are filled, any of the other three stations may be used, but only one at a time.

The target number of workers for operating the wash stations are as follows:

- Dunk tank with bubbler—one or two workers to wash and spin, and an additional one or two workers to pack and weigh
- Rinse conveyor—one worker to load and one worker to unload
- Barrel washer—one or two workers to sort and weigh
- Brush washer—one worker to load and an additional one or two workers to sort and count
- Bunched washing station—two or three workers, with the optional third worker serving as runner

Some crops can be washed at more than one station. Consult the **Wash Line Selection Guide** (Table 11.1) or refer to crop profiles in the [Crop Handbook](#).

Table 11.1 Wash Line Selection Guide.

<i>Wash Line</i>	<i>Crops Washed</i>
Barrel washer	Beets, carrots, parsnips, radishes, rutabaga, turnips
Brush washer	Bell peppers, cabbage, cucumber, eggplant, kohlrabi, pumpkin, summer squash, sweet peppers, watermelon, winter squash, zucchini
Bunched wash station	Beets, carrots, celery, fennel, ginger, green onions, leeks, turmeric, turnips
Dunk tank with bubbler	Arugula, bok choy, braising greens, broccoli, carrots, chard, collards, ginger, kale, lettuce, napa cabbage, spinach, sweet corn, turmeric, turnips
Rinse Conveyor	Celery, green onions, leeks, radish bunches, rhubarb
Unwashed	Brussels sprouts, bulb onions, cantaloupe, cauliflower, garlic, green beans, herbs, hot peppers, popcorn, potatoes, snap peas, sweet potatoes, tomatoes

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Dunk Tank with Bubbler

Prior to filling the dunk tank, shown in Figure 11.1, connect the drain hose at the west end of the tank, and close the valve. The valve handle will be perpendicular to the hose line when it is closed. Adjust the Dosatron, shown in Figure 11.2, for the correct SaniDate 15.0 rate (indicated on tape at lower left corner of mounting board), and open the two Dosatron valves (ball valve handles). Then shut off the main valve on the PEX tubing coming off the main packing shed hydrant. Remove the Hudson float valve at the end of one of the PEX hoses from its hook on the north wall and set it inside the tank. Open the water valve to begin filling the dunk tank.

The float valve will shut off once the tank reaches 100 gallons. Turn the water valve off and return the float valve to its holder on the wall. Flip up the switch on the north wall to activate the bubbler. Crops are dumped into the tank from the east side, off of the roller conveyor, and washed crops emerge into bins on the west side. Loose greens are spun in the salad spinners for one to two minutes per spin (Figure 11.3), while other crops like bunched items are packed and counted into their bins after the wash. If using the dunk tank for multiple crops, check water clarity and use peracetic acid test strips to verify the SaniDate level is at the correct ppm.



Figure 11.1 Dunk tank and bubbler. **Figure 11.2** Dosatron wall unit.



Figure 11.3 Salad spinners.

Rinse Conveyor

If using the rinse conveyor (Figure 11.4) for crops, raise the machine to inspect the interior. If the interior is dirty, use a hose to spray out and drain completely. Remove and spray off the screens, if needed, and then replace. Once clean, open the two water valves, one marked “Circulation” only and the second for both “Circ and HP” (high pressure). Lower the white valve at the base of the machine to close off the drain hose. Lower and lock the machine into place.

When using this machine for crops, workers wear an apron to stay dry. The circulation spray bars can be lowered to spray closer to the crop surface. Loosen the screws above the machine to set the height of the spray bars and tighten the screw in place at the desired height. When it is time to load crops, raise the front curtain and secure it above the rinse conveyor with a bin or other weight. This keeps the curtain from blocking the first wash stream. Slowly empty the bin contents onto the conveyor belt. Turn the machine on for circulation and adjust the speed of the conveyor belt. A second worker at the opposite end should be ready to pack and count the washed crops into clean bins.



Figure 11.4 Rinse conveyor.

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Barrel Washer

Inspect the interior of the barrel of the barrel washer (Figure 11.5) to ensure it is clean. Use a hose to spray down the inside, if needed. Before loading the machine, loosen the two screws on either side of the west side panel and raise the panel using the handle on top of the machine. Tighten the two screws to hold the panel in place in the raised position. This panel keeps the crops inside the barrel washer to finish the wash cycle before exiting.

When crops are ready to be loaded, turn the water valve on above the machine on the east side. Dump bins of roots into the barrel from the same side. Some items may need to be pushed by hand into the machine. Adjust the speed of the barrel on the control panel. Most roots are not washed in the barrel faster than the setting “4” to minimize any damage to the crop’s outer layer. Most crops need 10 or more minutes to be thoroughly washed. When crops are clean inside the barrel washer, turn on the Dosatron dispenser for the spray setting to wash crops for the last 45 seconds to 1 minute with SaniDate 15.0. After the SaniDate spray, lower the panel to allow the roots to exit the barrel onto the sorting table.

Brush Washer

Turn the switch box on to start the belt of the brush washer (Figure 11.6). Sanitize the loading belt with bleach solution. Adjust the Dosatron dispenser for the spray setting and turn on. Turn on the water valve on the north side of the machine, below the power switch. When loading crops, empty bins onto the belt. Adjust the last top brush higher or lower with the handle above the unit, accessed from the south side. Make sure the brush is in contact with the crop as it comes through the machine. Dump more bins of produce once the belt is clear but without overloading the sorting table or outpacing counters and sorters. A continuous supply of crops will keep everything moving through the machine at an even pace. The last bin load may need to be helped along through the machine by hand. Always raise the last brush before reaching in to pull any crops through.

The latex sponges at the end of the machine are replaced annually. Crops exit to the sorting table for sorting, packing, and counting.

Bunched Washing Station

When using the bunched washing station (Figure 11.7), workers wear rubber boots and an apron to stay dry. Two workers can manage the station at one time, facing each other from the north and south sides of the table. Be sure the table itself is clean and sanitized prior to use. Turn the water on at each of the two nozzles raised above the table. Adjust the spray pressure by twisting the nozzles, if needed.

Place unwashed crops on the west side of the table. Pass the crops through the water spray. Pack and count crops into clean bins, sitting on the east side of the table. Once a bin is filled, a runner can move the crops inside the packing shed to the cooler.



Figure 11.5 Barrel washer.



Figure 11.6 Brush washer.



Figure 11.7 Bunched washing station.

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Recordkeeping

The packing shed manager is responsible for verifying accurate records of crops harvested, washed, packed, and loaded into the cooler.

Workers are tasked with labeling bins with counts when each bin holds a different quantity of the crop. Label counts for the following crops: cucumbers, eggplant, kohlrabi, peppers, Red Meat or Watermelon radishes, summer squash, and zucchini. Macro bins should be labeled with amounts on the lid or side handle for cabbage, cantaloupe, pumpkin, sweet potatoes, watermelon, and winter squash. Items that are boxed or bagged, like garlic and onions, should also be labeled with their final counts. Only tomato bins are individu-

ally labeled with the weights, as weights vary between bins. These bins should also be labeled by type: heirloom, hybrid, or paste. Equal proportions of tomato types are sent to each distribution location. Tomatoes are stacked according to their type inside Cooler 3.

Workers record their own bin weights and bin counts on the white board at the time of loading into one of the coolers. Records on the white board always include date of harvest, crop name, count or weight (use “#” symbol to denote pounds), and total amount. Scales are always tared to account for empty bin weight. When different bins are being used, the scale is not tared, and bin weight is subtracted from the scale weight. Refer to Table 11.2, **Bin Weight Reference**.



Figure 11.10 Dark-green bin.



Figure 11.12 Yellow bin.



Figure 11.11 Light-green bin.



Figure 11.13 Brown/orange bin.

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Figure 11.14 Green, 12-inch hort bin.



Figure 11.15 Collapsible blue bin.



Figure 11.16 Red bucket.



Figure 11.17 Bread tray.



Figure 11.18 Tan bowl.

Table 11.2 Bin Weight Reference.

<i>Bin Type</i>	<i>Bin Weight</i>
Dark Green, bail arms, 13 inches tall	6.46 lbs
Light Green, bail arms, 10 inches tall	5.58 lbs
Yellow, 7 inches tall	3.96 lbs
Brown/Orange harvest, 10 inches tall	4.36 lbs
Green, 12 inches tall	5.60 lbs
Blue, collapsible, 10 inches tall	5.10 lbs
Red Bucket, 13 inches tall	1.18 lbs
Black Bread Tray, 6 inches tall	5.16 lbs
Tan Bowl	0.42 lbs

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The packing shed manager transfers totals to the CSA weekly share list. Based on totals, quantities for the share are decided in conjunction with the harvest manager. Total pounds or counts are divided by 275 for 250 shares. This allows for a 25-share buffer for errors or farm-stand sales. When counts are close, the 25-share buffer is omitted. Numbers are rounded down to the nearest whole number. This will result in excess, which can be divvied up by distribution location and sold at the farm-stand sales. Extra items above share numbers should be pulled into blue bins or a bin that is clearly labeled as extra for the farm stand. Most of the extra items are sent to campus, and a handful are retained for on-farm. Record the number of extra items allocated to campus and farm for retail sales in columns to the right of the share numbers on the white board.

Example: On Friday, 207 summer squashes were harvested. On Monday, 178 were harvested, and 158 were harvested on Wednesday. This gives a weekly total harvest of 543. If 543 is divided by 275, the result is 1.97. This is very close to two, so if the 25-share buffer is omitted, two summer squashes can go to each of the 250 shares, and there will actually be 43 extra summer squashes. While this extra is less than a 25-share buffer and is not enough to add an extra squash to one of the two distribution locations, 43 is an adequate leftover amount to sell at the farm stand.

The final recordkeeping step is for the packing shed manager to transfer all harvest totals to the harvest log. At the end of the week, the actual CSA share breakdown for the week is recorded next to the projected CSA box list, in order to track proximity to projections and calculate share value. All white board items for the week are double-checked as being recorded in the harvest log. After this, the white board can be erased.

Storage

There are three coolers for different crops. Cooler 1 is the main, original cooler located inside the packing shed. This cooler is set at 32°F to 34°F year-round.

Coolers 2 and 3 are both part of the packing shed expansion and are set at 50°F to 55°F. Cooler 2 is the larger one, on the east side of the expansion. Cooler 3 is the smallest of the coolers, on the west side of the expansion. Cooler 2 holds macro bins of potatoes, winter squash, and watermelon. Cool-

er 3 is primarily dedicated for tomatoes. Both Coolers 2 and 3 can hold cucumbers, eggplant, summer squash, and zucchini based on available space. Smaller bins of winter squash and potatoes may also be stored in Cooler 3.

When loading crops in coolers, separate items to different sides for farm and campus. Make sure all labels on bins are facing outward to be read easily. Stack the same crops together on one mini pallet. Start a new mini pallet for a different crop.

Crops—except tomatoes—are covered with plastic pallet covers at the end of the day to retain moisture (Figure 11.19). Do not cover any crop that had insufficient cooling time to reduce field heat. Macro bins are lidded.



Figure 11.19 Plastic pallet covers.

Clean Up

All compost bins are removed from the building, consolidated into the compost macro bin or lidded in smaller barrels, or taken by end of day to the compost piles at the back of the farm.

Packing shed floors are swept and, if needed, sprayed with a water hose and squeegeed into the floor trench drain. Do not sweep water outside the doors. All dirty bins are stowed neatly under the roller conveyors. All tanks are drained and sprayed.

At the end of the day, hydrants are shut off, the cooler door is locked, and all packing shed doors are closed.

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Other Notes

The packing shed manager double-checks that the number of bins in the cooler matches what is tabulated on the board. Counts on individual bins may have to be adjusted to evenly divide crops that are going to either farm or campus.

When multiple varieties of a crop are lumped together for the CSA shares (e.g., red and yellow bull's horn peppers), effort is made to equalize varieties for both CSA locations.

Extra items to be sold at the farm stand are pulled into blue bins that are designated for either campus or farm with labeling tape.

The clear poly curtains at the entrance of the cooler reduce energy loss from frequent opening and closing of the door (Figure 11.20). However, do not leave cooler doors open longer than necessary. During peak summer months, monitor the condenser inside the main cooler to be sure no ice is forming. If ice forms on the condenser, the cooler unit is turned off from the break box for an hour or more, until the ice dissolves. Overworking the condenser and allowing it to freeze can damage the components.

When loading crops onto the box truck, keep heavier items close to the rear doors to save energy in loading and unloading. Keep a stack close to the loading door that contains one bin of every item in the share for that week for easy offloading and quick setup. Blue bins with crops for the farm stand, and any other bins designated for farm stand, are also kept close to the loading door for ease in off-loading and separating from the CSA share items. Bins can be stacked four to five high in the truck. Maintain a center walkway within the truck, if able, for easier off-loading. Wheel wells are best used to hold bins of tomatoes. Tomato boxes are not stacked more than three high.



Figure 11.20 Plastic poly curtain.

12. SOP: HIGH TUNNEL AND SOLAR GREENHOUSE MANAGEMENT

Management of high tunnels and solar greenhouse structures includes several key topics:

1. Temperature and humidity control
2. Pest and disease monitoring
3. Structural repairs and safety

Temperature and Humidity Control

High tunnel cool-season crop management focuses on temperatures, cloud cover, and wind for optimal ventilation. Ideal high tunnel conditions for cool season crops will be 60°F inside with low relative humidity. Lowering humidity and temperature can prevent outbreaks of pests that thrive in warm, moist environments, notably aphids and whiteflies.

Start by checking the weather forecast for the following measurements:

- Daytime temperature highs
- Overnight temperature lows, which will include the low temperatures for the early hours of the following day, as the lowest temperature will often be reached between 4 a.m. and 7 a.m. the following morning
- Projected cloud cover (cloudy, partially cloudy, or clear)
- Wind speed, including the wind gusts and wind direction

Most prevailing winds at the farm come from the west and south. Venting instructions reflect opening doors (or curtains) away from prevailing winds, therefore the door or curtain to be opened for venting may change based on the forecast and the tunnel orientation.

Consult the chart for **High Tunnel Venting Protocols** to make management decisions (Table 12.1).

When temperature-sensitive crops are newly transplanted (particularly tomatoes), a few extra days are spent during their establishment to ease them into their new homes. This means not raising curtains as high to prevent bursts of cold air and occasional winds from shocking the new plants.

When row covering inside a tunnel for overnight low temperatures, workers should ensure that the row covers go all the way to the ground. In most cases, hoops are not required, and pavers are not needed to hold the covers down. Consult the chart for **High Tunnel Row Covering Protocols** to make management decisions (Table 12.2).

Tip: For efficient covering, two people should work together to cover plants (Figure 12.1). They can stand at opposite ends of the tunnel bed and pull the edges of the row cover over the plants and down to the soil level, keeping the fabric tight as they pull.



Figure 12.1 Two-person row covering.

Table 12.1 High Tunnel Venting Protocols.

<i>Daytime Temperatures</i>	<i>Cloud Cover</i>	<i>Venting Instructions</i>	<i>Open Time</i>	<i>Close Time</i>
Below freezing	Cloudy	Keep closed		
20°F-30°F	Clear	Open door away from prevailing wind halfway	9-10 a.m.	3-4 p.m.
30°F-40°F	Cloudy	Open door away from prevailing wind halfway	11 a.m.-12 p.m.	2-3 p.m.
30°F-40°F	Clear	Open door away from prevailing wind all the way	9-10 a.m.	3-4 p.m.
40°F-50°F	Cloudy	Open door away from prevailing wind all the way	11 a.m.-12 p.m.	2-3 p.m.
40°F-50°F	Clear	Open both doors	9-10 a.m.	3-4 p.m.
50°F-60°F	Cloudy	Open both doors	9-10 a.m.	3-4 p.m.
50°F-60°F	Clear	Open both doors, Curtain away from prevailing wind up 1'	9-10 a.m.	3-4 p.m.
60°F and above	Clear	Open both doors, Both curtains up all the way	9-10 a.m.	3-4 p.m.

12. SOP: HIGH TUNNEL AND SOLAR GREENHOUSE MANAGEMENT

Table 12.2 High Tunnel Row Covering Protocols.

<i>Outside Temperature Lows</i>	<i>Crops</i>	<i>Row Cover Weight</i>
30°F	Basil, Tomatoes, Peppers	Light/Mid
22°F	Asian Greens, Bok Choy, Green Onions (Parade), Napa Cabbage	Light/Mid
20°F	Arugula, Lettuce	Light/Mid
18°F	Beets, Celery, Radishes, Rutabaga, Strawberries, Turnips	Light/Mid
15°F	Asian Greens, Bok Choy, Green Onions (Parade), Napa Cabbage, Arugula, Lettuce	Heavy or Double Covers
12°F	Chard, Cilantro, Kale (Curly, Lacinato, Russian types)	Light/Mid
12°F	Beets, Celery, Radishes, Rutabaga, Strawberries, Turnips	Heavy or Double Covers
10°F	Carrots, Collards, Winter Radish	Light/Mid
Below 10°F	Green Onions (Evergreen Hardy White), Kale (Vates), Spinach	Light/Mid
Below 8°F	Chard, Cilantro, Kale (Curly, Lacinato, Russian types)	Heavy or Double Covers

Row covers are always removed first thing the next morning when temperatures are at a safe level, in order to expose plants to as much sunlight as possible and reduce relative humidity around the plants. Place bunched row covers not in use between beds of plastic or on outer edges inside the tunnels.

Thermometers connected to Wi-Fi and weather stations aid in decision-making by tracking temperatures inside the tunnels, under row covers, and at plant level (Figures 12.2 and 12.3). Many devices can be connected to a smartphone app for easy checking and monitoring even when away from the tunnel. Devices are placed in an area that is near plant level but where they will be easily seen and not stepped on. Weather stations are mounted on T-posts by bed edges in order to not interfere with row covers. Warmest temperatures will occur in the middle of the structures, while edges will be slightly cooler.



Figure 12.2 Thermometer connected to Wi-Fi.



Figure 12.3 Weather station.

12. SOP: HIGH TUNNEL AND SOLAR GREENHOUSE MANAGEMENT

Spring brings large windstorms to central Kentucky. Venting tunnels in windy conditions requires some alterations to the management plan in Table 1, based on wind speed and direction. High winds can cause damage to the plants inside tunnels, as well as to the structures themselves (Figure 12.4). In general, close doors and curtains against the prevailing wind and open those opposite to still allow ventilation. Consult the chart for **High Tunnel Wind Response Protocols** to make the best decisions (Table 12.3).

The solar greenhouse has unique temperature management protocols. This structure will heat up faster than most high tunnels and can also buffer low night temperatures better than high tunnels. The solar greenhouse is an ideal spot for getting more sensitive crops to survive in the middle of winter. Unlike the high tunnels, the solar greenhouse only has three venting options: east doors, west doors, and a south curtain. The south curtain is raised and lowered by aid of a winch (Figure 12.5). Turn clockwise or toward the south to open, and turn counter-clockwise to close.

The solar greenhouse will be vented more aggressively to get more airflow inside the structure. Consult **Solar Greenhouse Venting Protocols** for management decisions (Table 12.4).



Figure 12.4 Windstorm-shifted tunnel. Windstorms moved tunnels when anchors had not been fully installed. Note the structure has been picked up and moved diagonally in the plot.



Figure 12.5 Winch to raise solar greenhouse curtain.

Table 12.3 High Tunnel Wind Response Protocol.

<i>Wind Speed</i>	<i>Direction</i>	<i>Mitigation</i>
20 mph gusts or more	S, SW, SE	Close South Curtain
20 mph gusts or more	N, NW, NE	Close North Curtain
20 mph gusts or more	E	Close East Door
20 mph gusts or more	W	Close West Door
40 mph gusts or more	Any	Close Entire Structure

Table 12.4 Solar Greenhouse Venting Protocols.

<i>Daytime Temperatures</i>	<i>Cloud Cover</i>	<i>Venting Instructions</i>	<i>Open Time</i>	<i>Close Time</i>
Below freezing	Cloudy	May keep closed, or open East door and Curtain 1/4	11 a.m.-12 p.m.	2-3 p.m.
20°F-30°F	Clear	East door open, Curtain up 1/4	9-10 a.m.	3-4 p.m.
30°F-40°F	Cloudy	East door open, Curtain up 1/2	11 a.m.-12 p.m.	2-3 p.m.
30°F-40°F	Clear	East and West doors open, Curtain up 1/2	9-10 a.m.	3-4 p.m.
40°F-50°F	Cloudy	East and West doors open, Curtain up 3/4	11 a.m.-12 p.m.	2-3 p.m.
40°F-50°F	Clear	East and West doors open, Curtain up 3/4	9-10 a.m.	3-4 p.m.
50°F-60°F	Cloudy	East and West doors open, Curtain up all the way	9-10 a.m.	3-4 p.m.
50°F-60°F	Clear	East and West doors open, Curtain up all the way	9-10 a.m.	3-4 p.m.
60°F and above	Clear	East and West doors open, Curtain up all the way	9-10 a.m.	3-4 p.m.

12. SOP: HIGH TUNNEL AND SOLAR GREENHOUSE MANAGEMENT

Pest and Disease Monitoring

Both insects and mammals can cause major damage to crops in high tunnels. Since these structures stay warmer year-round, insects and animals find refuge in tunnels. Pest outbreaks can also occur rapidly.

Monitor key insect pests like aphids, fungus gnats, spider mites, thrips, and whiteflies using yellow sticky cards placed at plant level. Cards are checked weekly, and notes are taken on number and species for each quadrant on the cards. The number and species of insects will help to determine the action threshold. A high tunnel monitoring form may be used. (See “[High Tunnel Weekly Monitoring Form](#)” in ID-235 by UK Vegetable IPM Team, 2018.)

When temperatures are more consistently above 65°F, biocontrol with lady beetles or other beneficial insect releases inside the tunnels is an option. However, unless the structures are netted, there is no guarantee these insects will stick around. Do not release beneficials if intending to manage pests by spraying pesticides, which could also have non-target effects on them.

Occasionally slugs will become troublesome, particularly for lettuce crops. A simple method of trapping is to bury a plastic cup in the soil until the lip is at soil level. Fill the cup partway with beer. Slugs will be attracted to the beer, fall in the cup, and become trapped. Slugs emerge at nightfall and in overcast weather, so have these in place overnight and during periods of prolonged cool, cloudy weather.

Small mammals like voles and mice should be monitored and controlled using snap traps. Plastic snap traps can be rinsed off and reused. Traps can be hidden under small boxes with an opening for entry. This box should be weighted with a small rock or paver to keep it from being disturbed. The box will obscure the trap to lure the pest inside, but it also keeps workers from accidentally stepping on them or disturbing them. Approximately four or five traps per tunnel may be needed. Traps can be set with a small amount of peanut butter, and bird seed may also help to attract them.

Larger mammals like groundhogs must be caught with larger traps via catch-and-release. Animals can be lured into the traps with pieces of melon. The traps can also be obscured with boxes or cardboard.

All traps are monitored daily. If any animal is caught in a snap trap, it is disposed of in the dumpster. The trap is rinsed, baited with peanut butter if needed, and reset. Slug traps can be rinsed and refilled weekly. If larger animals are caught in catch-and-release traps, notify the CSA manager and farm superintendent to assist with removal.

Structural Repairs and Safety

There are a few structural components to pay attention to within the high tunnels. The sliding doors slide along a horizontal track (Figure 12.6). Occasionally the bolts loosen and the door can fall off the track. It takes two people to fix, with one person lifting the door and the second on a ladder reattaching the bolt to the door.

When closing doors, be sure that they are secured within the braces to hold them tight.

Doors on the solar house are propped open with two pavers on each door (Figure 12.7).



Figure 12.6 Sliding door hardware.



Figure 12.7 Solar greenhouse doors propped open.

12. SOP: HIGH TUNNEL AND SOLAR GREENHOUSE MANAGEMENT

When raising and lowering rolling side curtains, careful control is maintained during the entire raising and lowering process. These curtains are under tension, which increases as they are raised. If a worker loses a grip on the handle crank, it will ricochet back, which can cause injury. All workers must be trained on raising and lowering side curtains before attempting to use the cranks (Figure 12.8). In addition, when closing the curtains, workers walk the length of the sides and ensure the far ends are not snagged and have made contact with the baseboards. If any curtains have gotten caught, they are tapped down into place with one's foot (Figure 12.9).

With heavy snow, a broom or pole with a tennis ball on the handle can be used to gently push up the plastic from underneath. Workers start at the top and work the tool down the gothic arch to encourage the snow to slough off. This will help keep weight off the structure and allow sunlight into the structure for the plants.

During thunderstorms, the high tunnels are not safe places to continue working. Workers must leave the structures and, if shelter is needed, head to the packing shed.

Small tears in plastic are repaired with poly patch. The surface must be dry before adhering the poly patch over the hole. The patch is reinforced with tape around the edges. The poly patch will hold better when cut in a rounded shape rather than a squared one. Rounded edges are not as subject to peeling easily.

Any other structural issues that are spotted are reported to the CSA manager.



Figure 12.8 Handle crank on high tunnel side curtains.



Figure 12.9 Tapping curtain poles down with one's foot.

CSA Workbooks

In this section, two workbooks outline key components of the CSA planning process.

The [**Share and Field Planner**](#) includes worksheets for projecting shares, crop planning, and scheduling.

The [**Fertility Planner**](#) covers how to credit nitrogen in the soil and from cover crops to determine crop nitrogen requirements.

Click on the bolded titles to access and view the workbooks.

Appendix

Glossary

Backpack Spray — Method of pesticide application using a tank worn on one's back and dispersed with a handheld wand or blower. They can be powered manually or by gas.

Bare Ground — One of the production systems at UK-CSA, which describes the environment in which the plants grow, on bare soil that has been formed into beds.

Barrel Wash — One method of post-harvest handling to hydrocool and wash root crops that have had their greens removed, utilizing a long, rotating drum and water-spraying nozzles to dislodge soil.

Basket Weed — One method of between-row weed cultivation for thread-stage weeds, where weeds are uprooted or crushed by rotating metal bars arranged in a cylindrical shape referred to as a basket.

BCS — A walk-behind tractor used in tunnels and biointensive plots.

Beneficials — Insects that aid plants by pollination or by preying on insects that cause feeding damage to crops. A few examples include bees, parasitic wasps, lacewings, and assassin bugs.

Biointensive — One of the production systems at UK-CSA, characterized by smaller field (or plot) size and more plants being grown in each area. Frequently plants are grown on three, four, or six rows per bed to maximize yield on a smaller land area. Management of these plots is accomplished primarily with the use of a BCS walk-behind tractor and hand tools.

Blind Cultivate — The practice of cultivating a field without regard to the placement of the field rows, with the intent of disturbing the soil's top layer and uprooting newly germinated weeds.

Bolting — The biophysical process of a plant beginning to produce a flower stalk and set seed, which can result in lower plant quality or a crop unfit for consumption.

Boom Spray — A method of pesticide application using a tractor's PTO-powered mixing tank and a spray bar that can be extended over the field and raised or lowered to apply the pesticides right above the plant canopy.

Broadfork — A hand tool with several sturdy tines that help break soil compaction when sunk below the soil surface. It is used in biointensive and tunnel systems.

Brush Wash — One method of post-harvest handling to hydrocool and wash vegetables that can withstand some agitation from rotating brushes. It is frequently used with cucurbits, peppers, and eggplants.

Bubbler — A method of injecting air into a dunk tank of water to create bubbling and agitation, which can wash crops like leafy greens more effectively when they are submerged.

Buffer Strips — Areas of field plots, frequently at the long edges, where a cover crop is grown instead of a cash crop to provide beneficial insect habitat, biodiversity, weed control, and more organic matter for the field.

Caterpillar Tunnel — One season extension structure that is smaller and easier to move than a high tunnel, using ropes laced from side to side over the structure's peak to keep the plastic held down tight; it is sometimes called a "cat tunnel" for short.

Chisel — One method of tillage frequently employed to help break down and incorporate the previous season's crop residues.

Compaction — The state of soil when soil aggregates are tightly compressed and air pockets have been reduced, hindering the flow of air and water as well as the growth of roots and plants.

Compost — Partially decomposed plant material that contributes to soil tilth by adding organic matter, increasing water-holding capacity, and retaining nutrients.

Coupler — An irrigation component that is used to link two sections of irrigation lines to each other.

Cover Crop — A crop that is not grown as a cash crop but is planted for nonmonetary benefits, like weed control and soil health.

CSA — Short for "community supported agriculture," it is a method of direct marketing a farm's products to a particular group that pays for their produce in advance of the growing season to offset up-front input and labor costs the farmer faces.

Curing — A method of post-harvest handling to dry the crop's outer skin and prepare it for long-term storage.

Direct Seed — One method of starting crops, in which seeds are placed directly in the field's soil at the time of planting.

Disc — A weed cultivation component that slices through residues when pulled behind a tractor.

Dosatron — A water-powered dosing tool used to precision-inject fertilizer or sanitizer into water lines.

Drag Bin — A bin placed in direct contact with the soil, below a second bin that is nested inside of it to hold the harvested crop; this bin is employed to reduce soil buildup and chance of contamination on the crop itself.

Drip Tape — One method of crop irrigation, wherein water flows through narrow plastic tubes and drips out of slits spaced apart at set intervals (6, 8, or 12 inches) on top of the tape; this tape can be laid on top of the soil or buried three to four inches subsurface.

DTM — Short for "days to maturity," this is the average number of growing-degree days from planting to harvest for a given crop variety. This value is sometimes calculated from direct seeding, or it can also be calculated from time of transplant.

Emitter — An irrigation valve that connects the header irrigation lines to the drip-tape lines in the bed and can be manually turned on and off.

Fertigation — The process of giving plants supplemental fertilizer by injecting it into the irrigation water.

Finger Weed — One method of in-row weed cultivation, using a tractor-pulled implement with flexible spinning tines to maneuver next to and between plants.

Flail Mow — One method of cover-crop termination, as well as management of crop residues, that involves chopping the biomass into small pieces that will decompose quickly.

Flame Weed — One method of blind-weed cultivation, when a propane-powered flame comes into contact with the soil surface to kill any newly emerged or emerging weeds.

Frost-free Days — The interval between the last expected frost at the start of the growing season and the expected first day of frost at the end of the season. The frost dates are determined based on when there is a 50 percent chance of frost for a given geographic area. In Zone 6b, the last frost date is around April 20, and the first frost date is around October 23. These dates can change from year to year.

FSMA — The Food Safety Modernization Act, enacted by the U.S. Congress in 2018, which outlines practices and requirements for food producers to better protect public health and prevent foodborne illnesses. For more information, see www.fda.gov/food/guidance-regulation-food-and-dietary-supplements/food-safety-modernization-act-fsma.

GAP — Short for “Good Agricultural Practices,” this is a set of practices recommended for agricultural producers to prevent foodborne illnesses; an elective third-party audit can be given to certify that certain farm operations are in compliance with these protocols and may be required by certain buyers of a farm’s products. For more information, see www.ams.usda.gov/services/auditing/gap-ghp.

Hardening Off — The process of slowly acclimating plants to outdoor weather conditions and fluctuations as they transition out of the shelter of a greenhouse or other protected environment.

Harrow — A weed cultivation tool with tines or teeth that are dragged across the soil surface to break up soil clods, residues, and kill weeds.

Haygrove — One season extension structure that consists of tall metal bows covered in plastic overhead but remains open to the elements on all four sides.

High Tunnel — One season extension structure that serves as an unheated greenhouse, harnessing the sun for warmth; this structure is covered above and on all four sides with plastic and is ventilated by the action of opening and closing doors and side curtains.

Hot Bed Weeder — A hand-weeding tool in the shape of a question mark, sharpened on all edges.

Hot Water Treatment — A cultural practice for preventing seed-borne plant diseases by heating seed to a given temperature threshold for a set amount of time to kill pathogens without harming the seed’s viability.

IPM — Short for “Integrated Pest Management,” this refers to a suite of practices to control and manage pests, including both insects, weeds, and diseases; practices may include cultural, mechanical, biological, and chemical methods of pest control.

Jang Push Seeder — A precision seeder that singulates seeds and can be easily adjusted and pushed to direct-seed a crop; this tool is frequently used in high tunnels and in biointensive field plots.

Knife Sheath — A simple knife carrier for workers to safely bring their harvest knives to the field, this carrier is made from recycled irrigation layflat and can be worn on a worker’s belt and sanitized before and after use to keep the knife blade secure and clean between uses.

KYFSC — Short for “Kentucky Farm Share Coalition,” this group oversees the CSA voucher programs and employer-partnerships with CSA farms. For more information, see www.kyfarmshare.org/.

Living Mulch — A cover crop grown between rows or beds of plants that can be managed by mowing during the growing season; it covers the soil, outcompetes weeds, and adds organic matter to the field.

Manifold — A custom-built irrigation component used to divert the flow of water and reduce water pressure from the main irrigation supply lines before funneling water into individual fields.

MaterMacc Vacuum Seeder — A precision, PTO-powered seeder for direct-seeding crops into a bare-ground field.

Mechanical Transplanter — A tractor-pulled implement that is powered by a drive wheel to consistently time the planting of small transplants into a bare-ground field bed.

Nitrogen Credit — The amount of nitrogen presumed to be available to plants (PAN, or plant available nitrogen), calculated from compost, cover crops, and past fertilizer applications.

NOP — The National Organic Program, which is a federal regulatory program that sets the standards for organic certification. For more information, see www.ams.usda.gov/about-ams/programs-offices/national-organic-program.

OAK — The Organic Association of Kentucky, a nonprofit organization that connects and supports organic farmers in the state, and also supports the work of the KYFSC. For more information, see www.oak-ky.org/.

OFU — The Organic Farming Unit, located at the University of Kentucky’s Horticulture Research Farm (HRF), consists of 35 acres that are USDA-certified organic. All organic-focused research, teaching, and extension efforts are connected to this unit; the UK-CSA is one entity at the OFU.

OMRI — The Organic Materials Review Institute, which provides guidance about which inputs are approved for certified organic use on farms. For more information, see www.omri.org/.

Organic — The USDA defines it as a labeling term that indicates a food or other agricultural product has been produced according to the USDA organic standards.

The organic methods integrate cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance and conserve biodiversity. For more information, see www.usda.gov/topics/organic.

Packing Shed — The location at the OFU where harvested crops are taken to be washed, processed, sorted, counted, packed, cooled, and stored.

Persephone Period — A term coined by Eliot Coleman, this is the time of year when daylength falls below 10 hours a day, and this time is categorized by reduced or little plant growth. In Central Kentucky, the Persephone Period starts around November 21 and ends around January 20.

Pest — A pest can be any entity that causes harm to a plant and may be an insect, another plant (like a weed), or a pathogen.

Plant Hardiness Zone — A zone is a defined geographic area based on the average annual winter minimum temperature, divided into 10°F sectors; these areas help to determine which plants will thrive in each location. The plant hardiness zone for Central Kentucky is 6b, which has an average winter minimum temperature of -5°F to 0°F.

Plastic Cultivate — A method of weed cultivation with custom tractor-mounted cultivation tools to remove weeds on the shoulders of beds covered in plastic mulch.

Plastic Mulch — A material installed over the soil on a raised bed prior to planting that acts as an inorganic barrier to weeds, reduces water evaporation and lessens soil erosion risk.

Plasticulture — One of the production systems at UK-CSA in which crops are grown on beds covered with plastic mulch.

Plow Pan — A section of the soil's profile where repeated tillage creates a hard, compacted layer that can create drainage problems and negatively affect plant health; it can be addressed by the action of subsoiling every few years.

Plug — The term for a small plant started in a tray within a greenhouse or other controlled environment that will be planted in the field.

Potting Media — The growing medium for a greenhouse-produced seedling.

Potting Up — The process of moving a greenhouse-grown plant from a small-cell tray to a larger-cell tray to allow for the plant to get bigger.

ProTek Net — A physical barrier to prevent insect damage and predation, made of a mesh net that allows only air, rain, and pesticide applications to penetrate down to the crop. The mesh sizes vary to correspond to the size of the pest that is desired to be excluded.

PTO — Stands for power take-off, this is the mechanism to transfer power from an engine on a tractor to an implement; the PTO shaft is the part of the implement that connects to the tractor for this power transference.

Rotation — A cultural practice to prevent insect and disease issues that necessitates moving crops within a given botanical family, or those sharing similar characteristics, from one field to another each year and allowing for a break of several seasons before the same crop family returns to that area again.

Rototill — A method of secondary tillage that breaks down soil clods and allows for a fine tilth of soil ready for planting.

Row Cover — A physical barrier used to prevent insect damage and predation in some circumstances but mainly employed to protect vulnerable crops from cold temperatures and wind. The covers will reduce light transmission corresponding to their thickness but still allow air and water to reach the crop underneath.

SaniDate — The trade name for a type of wash water sanitizer that is OMRI approved for food-safe agricultural production.

Scuffle Hoe — A type of long-handled tool that consists of a U-shaped, double-sided blade that rocks backward and forward with the motion of the handle to shallowly cultivate the top inch of soil. This tool is primarily used between rows of plants or on the shoulders of beds.

Seedbed Roller — This tool is a metal wire mesh drum with moveable metal dibbles that can be snapped into the mesh and arranged in different patterns and spacings on the drum's surface; the roller is manually pushed or pulled to create a dibbled grid for hand-planting in tunnel and biointensive field plots.

Solar Greenhouse — A type of season extension structure, also called a "deep winter" or "Chinese" greenhouse, that relies on the sun to heat a north-facing wall lined with black-painted water barrels or side-by-side, black, corrugated-metal walls filled with sand, which will retain the heat of the day and radiate it into the structure for significant temperature buffering overnight.

SOP — Short for "standard operating procedures," these documents provide step-by-step guidelines and how-tos, using words and visuals for the purpose of instruction, training, and standardization of on-farm operations.

Spade — A type of primary tillage that lifts soil with rotating spades rather than inverting soil.

Splicer — An irrigation component that connects two pieces of drip tape irrigation lines. When irrigation lines spring a leak, these components allow the leak to be cut out of the line and the two sides re-attached to one another to resume normal water flow.

Stale Seed Bed — A method of pre-plant weed cultivation over an established bed's surface that only shallowly cultivates the top one to two inches of soil for minimal disturbance.

Subsoiler — A tractor-pulled tool consisting of two long shanks that are pulled through the soil profile and create deep furrows to break compaction below the plow pan.

Tillage — The process of working and turning over soil to prepare it for planting.

Tilth — The physical soil qualities that are suitable for plant growth, including stability of soil aggregates, water-holding capacity, porosity, soil biota and microflora, and drainage rates.

Tilther — A long-handled tool activated by a battery-powered drill that incorporates soil amendments like compost and fertilizer prior to planting.

Tine Weed — A type of blind weed cultivation over the tops of emerged plants with the action of vibrating metal tines that remove thread-stage weeds.

Transplant — This word is used as a noun to refer to a plant plug from the greenhouse when it is ready for the field. When used as a verb, this refers to the process of planting a plug in the field. Plugs can be transplanted into both bare-ground and plasticulture systems.

Voucher — A monetary credit offered to UK employees on a UK health plan to reduce the cost of a CSA share.

Water Wheel — A tractor-pulled implement that uses metal wheels with preset dibbles to punch holes into beds covered with plastic mulch, inject water into the holes, and allow workers to hand-plant a plug into the bed.

Weed Seed Bank — The condition of a soil profile holding innumerable weed seeds that will germinate given the right conditions. Tillage is one of the primary ways that the weed seed bank is disturbed and amplifies the weed pressure for the following year, which must be managed by cultivations and cultural control tactics.

Wheel Hoe — A long-handled tool with a wheel that allows it to easily travel down the length of the bed while cultivating weeds located between beds or in wheel tracks within a field using an attached U-shaped, double-edged blade.

Wholesale — A marketing strategy to sell products in bulk to larger buyers, like restaurants, grocery stores, and food processors.

Winstrip — A type of tray used in transplant production in a greenhouse, with an offset grid pattern and slits on each of the individual plant cells that are located adjacent to an empty column, allowing for air pruning of roots, which reduces the risk of a plant becoming rootbound.

You-Pick — A marketing strategy to allow customers to come onto the farm to pick their own crops. At UK-CSA, the you-pick is a designated area of the farm and is limited to CSA members and their families only, as an included benefit of membership.

Resources

Seeds and Plants

Cottle Farms
www.cottlefarms.com

Fedco Seeds
www.fedcoseeds.com

Green Cover
www.greencoverseed.com

Hancock Seed Company
www.hancockseed.com

Harris Seeds
www.harriseseeds.com

Hawaii Clean Seed
www.hawaiianorganicginger.com

High Mowing Organic Seeds
www.highmowingseeds.com

Indiana Berry and Plant Co.
www.indianaberry.com

Johnny's Selected Seeds
www.johnnyseeds.com

Jones Family Farm
www.jonesfarmsonc.com/HowToOrderSPSeedsPlants.html

Lewis Seed Company
www.lewisseedcompany.com/

The Maine Potato Lady
www.mainepotatolady.com/productcart/pc/home.asp

Nourse
www.noursefarms.com

Seedway
www.seedway.com

Southern Exposure Seed Exchange
www.southernexposure.com

Territorial Seed Company
www.territorialseed.com

Tomato Fest
www.tomatofest.com

Totally Tomatoes
www.totallytomato.com

Uprising Seeds
www.uprisingorganics.com

Welter Seed and Honey Co.
www.welterseed.com

Wild Garden Seed
www.wildgardenseed.com

Tools

A.M. Leonard
www.amleo.com

Earth Tools
www.earthtools.com

Farmers Friend
www.farmersfriend.com

Johnny's Selected Seeds
www.johnnyseeds.com

Neversink Farm
www.neversinktools.com

Other Supplies

ARBICO Organics
www.arbico-organics.com

Berry Hill Irrigation, Inc.
www.berryhilldrip.com

Berry Seeder Company
www.berryseeder.com

BioSafe Systems
www.biosafesystems.com

Darling Ingredients
www.darlingii.com

Dubois Agrinovation
www.duboisag.com/us_en

Fetpak Inc.
www.fetpak.com

Gemplers
www.gemplers.com

Great Lakes IPM
www.greatlakesipm.com

Johnny's Selected Seeds
www.johnnyseeds.com

Martin's Nursery Wholesale and Retail
Liberty, KY

Nationwide Industrial Supply
www.nationwideindustrialsupply.com

Purple Mountain Organics
www.purpletools.net

QC Supply
www.qcsupply.com

Saveway Supplies Inc.
www.saveties.com

Schrock's/Lincoln County Produce Auction
Crab Orchard, KY

Seven Springs Farm Supply
www.7springsfarm.com

Ideal Sciences
www.tempstick.com

Uline
www.uline.com

Vermont Compost Company
www.vermontcompost.com

WebstaurantStore
www.webstaurantstore.com

Books

Coleman, Eliot. *The New Organic Grower*. Vermont: Chelsea Green Publishing, 1995.

Dawling, Pam. *Sustainable Market Farming*. Canada: New Society Publishers, 2013.

Dawling, Pam. *The Year-Round Hoophouse*. Canada: New Society Publishing, 2018.

Fortier, J.M. *The Market Gardener*. Canada: New Society Publishers, 2014.

Hartman, Ben. *The Lean Farm*. Vermont: Chelsea Green Publishing, 2015.

Henderson, Elizabeth, and Robyn Van En. *Sharing the Harvest*. Vermont: Chelsea Green Publishing, 2007.

Huntley, Simon. *Cultivating Customers*. Lioncrest Publishing, 2016.

Mohler, Charles L., and Sue Ellen Johnson. *Crop Rotation on Organic Farms*. NRAES, 2009.

Slama, Jim, and Atina Duffley. *Wholesale Success*. New York: FamilyFarmed, 2013.

Wiswall, Richard. *The Organic Farmer's Business Handbook*. Vermont: Chelsea Green Publishing, 2009.

Videos

[UK Organic Farming Unit:
Bare-ground Production
Post-Harvest Handling
Dunk Tank Bubbler
AZS Rinse Conveyor](#)

Food Safety/GAP:

[Worker Health and Hygiene – Produce Best Practices
Training](#)
[Pre-Harvest Wildlife Check – Produce Best Practices
Training](#)
[Food Storage Boxes – Produce Best Practices Training](#)

Click on the titles to view the associated videos.

UK-CSA Food Safety Manual

As a result of the farm going into wholesale production in 2015, 2016, and 2018, the food safety manual was developed as part of compliance with third-party GAP certification. Since then, this manual continues to inform staff, students, and visitors regarding the farm's active, ongoing commitment to food-safe practices.

UK-CSA COVID-19 Protocols

In the spring of 2020, the UK-CSA farm continued operations during the COVID-19 pandemic. This pandemic challenged the UK-CSA farm to re-evaluate on-farm practices for not only food safety but worker and customer safety as well. This document details how UK-CSA modeled safe and sustainable farming practices during the challenging time of the pandemic.

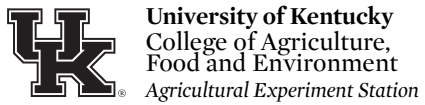
Click on the titles to view the full documents.

References - UK-CSA Farming System

1. Steve McFadden, "The History of Community Supported Agriculture," Rodale Institute, last modified January 2004, <https://rodaleinstitute.org/blog/the-history-of-community-supported-agriculture/>.
2. "Community Supported Agriculture," USDA Alternative Farming Systems Information Center, last modified May 2019, <https://www.nal.usda.gov/afsic/community-supported-agriculture>.
3. "Kentucky Proud CSA," Kentucky Proud, accessed <https://kyproud.com/csa/>.
4. Tiffany Thompson, "UK-CSA Economic Analysis," Center for Crop Diversification, July 2017, <https://www.uky.edu/ccd/tools/budgets/UKCSAEconomicAnalysis>.
5. "In Kentucky, 50 percent of the so-called Phase I tobacco settlement funds were used instead to assist tobacco farmers in diversifying into other crops." (Mathis & Snell, 86) Gilbert L. Mathis and William M. Snell. "Tobacco in Transition: An Overview of Sixty-Six Years of Partnership Between Producers, Processors and Politicians," *Essays in Economic & Business History* Vol XXV, No. 1 (2007): 79-94, <https://www.ebhsoc.org/journal/index.php/ebhs/article/view/174/155>.
6. Tiffany Thompson, "UK-CSA Economic Analysis," Center for Crop Diversification, July 2017, <https://www.uky.edu/ccd/tools/budgets/UKCSAEconomicAnalysis>.
7. ID-36: Vegetable Production Guide for Commercial Growers, University of Kentucky Department of Vegetable Crops Extension & Research Horticulture, last modified 2020-2021, <http://www2.ca.uky.edu/agcomm/pubs/id/id36/id36.pdf>.
8. Charles L. Mohler & Sue Ellen Johnson, *Crop Rotation on Organic Farms: A Planning Manual* (New York: NRAES, 2009).
9. "Web Soil Survey," USDA NRCS, accessed April 2021, <https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>.
10. W.O. Thom et al. "Taking Soil Test Samples," UK Cooperative Extension Service, accessed April 2021, <http://www.ca.uky.edu/agc/pubs/agr/agr16/agr16.pdf>.
11. Taryn Kennedy, "Compost Standards," OMRI, last modified May 2019, <https://www.omri.org/compost-standards>.
12. Mark Williams, "Winning the Battle Against Weeds: An Integrated Approach to Sustainable Weed Control," (presentation, OAK, March 2018).
13. Rates based on historical records and AGR-18 recommendations. Knott et al. "Grain, Forage, and Cover Crop Guide for Kentucky," University of Kentucky Cooperative Extension Service, last modified July 2020.
14. Bruce Hoskins, "Nutrient Content, Availability, and Release Rates from Natural Fertilizers," University of Maine, accessed April 2021, https://newenglandvfc.org/sites/newenglandvfc.org/files/content/proceedings2015/22_1_Hoskins.pdf, Figure 1.
15. "Kentucky State Climate Summaries," NOAA National Centers for Environmental Information, accessed April 2021, <https://statesummaries.ncics.org/chapter/ky/>.
16. "Irrigation Efficiency and Uniformity, and Crop Water Use Efficiency," University of Nebraska Lincoln Extension, accessed April 2021, <https://extensionpublications.unl.edu/assets/pdf/ec732.pdf>, Table 2.
17. Jim Slama and Atina Duffley, *Wholesale Success* (Family-Farmed, 2013), p.37.
18. F.M.R. Isenberg, "Storage of Home Grown Vegetables," Cornell University, accessed April 2021, <http://chemung.cce.cornell.edu/resources/storage-guidelines-for-fruits-vegetables>.
19. Adapted from Pam Dawling, "Storage Vegetables for Off-Season Sales," (Powerpoint slides, slideshare.net, 2017).
20. Rossi, Jairus J.; Woods, Timothy A.; Allen, James E., IV. 2017. "Impacts of a Community Supported Agriculture (CSA) Voucher Program on Food Lifestyle Behaviors: Evidence from an Employer-Sponsored Pilot Program," *Sustainability* 9, no. 9: 1543. <https://doi.org/10.3390/su9091543>.
21. "The 2015 CSA Farming Annual Report," CSA Solutions Hub, accessed April 2021, <http://www.memberassembler.com/hub/csa-report>.
22. Ryan E. Galt et al. "Retaining Members of Community Supported Agriculture (CSA) in California for Economic Sustainability: What Characteristics Affect Retention Rates?" *Sustainability* 2019, 11, 2489; doi:10.3390/su11092489.

References - Standard Operating Procedures (SOPs)

1. "Web Soil Survey," USDA NRCS, Accessed April 2021, <https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx>.
2. Toro, Accessed April 2021, <https://www.toro.com/agriculture/calculator/index.html>.
3. Adrian Card and Troy Bauder, "Determining Irrigation Run Times with Drip Tape Specialty Crops – 5.623," Colorado State University Extension, last modified September 2019, <https://extension.colostate.edu/topic-areas/agriculture/determining-irrigation-run-times-with-drip-tape-on-specialty-crops-5-623/>.
4. "Soil Water Basics," Irrrometer, Accessed April 2021, <https://www.irrometer.com/basics.html>.
5. "Crop Coefficients for Use in Irrigation Scheduling," British Columbia Ministry of Agriculture, Food and Fisheries, last modified October 2001, <http://irrigation-toolbox.com/ReferenceDocuments/Extension/BCExtension/577100-5.pdf>.
6. "Irrigating Vegetable Crops," UMass Extension Vegetable Program, University of Massachusetts Amherst, last modified January 2017, <https://ag.umass.edu/vegetable/fact-sheets/irrigating-vegetable-crops>.
7. Suat Irmak et al. Table 2, "Irrigation Efficiency and Uniformity, and Crop Water Use Efficiency," University of Nebraska Lincoln Extension, 2011, <https://extensionpublications.unl.edu/assets/pdf/ec732.pdf>.
8. J.K. Kemble & D.C. Sanders, "Basics of Vegetable Crop Irrigation," Alabama Cooperative Extension System, last modified November 2000, <https://www.irrometer.com/pdf/research/ANR-1169.pdf>.
9. Elsa Sanchez, "Vegetable Planting and Transplanting Guide," PennState Extension, last modified July 2011, <https://extension.psu.edu/vegetable-planting-and-transplanting-guide>.
10. Lyndon Kelley, "Planting and Irrigation in the Same Week?," MSU Extension, last modified May 2017, https://www.canr.msu.edu/news/planting_and_irrigation_in_the_same_week.
11. "Irrigation Strategies for Vegetables," University of Minnesota Extension, last modified 2020, <https://extension.umn.edu/vegetables/irrigation-strategies-vegetables#-soil-water-tension-or-matric-potential-sensors-2659661>.
12. Dierdre Holcroft, "Water Relations in Harvested Fresh Produce," The Postharvest Education Foundation, last modified May 2015, <http://www.postharvest.org/Water%20relations%20PEF%20white%20paper%20FINAL%20MAY%202015.pdf>.



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