On-Farm Cold Storage

of Fall-Harvested Fruit and Vegetable Crops

PLANNING – DESIGN – OPERATION

Scott A. Sanford and John Hendrickson

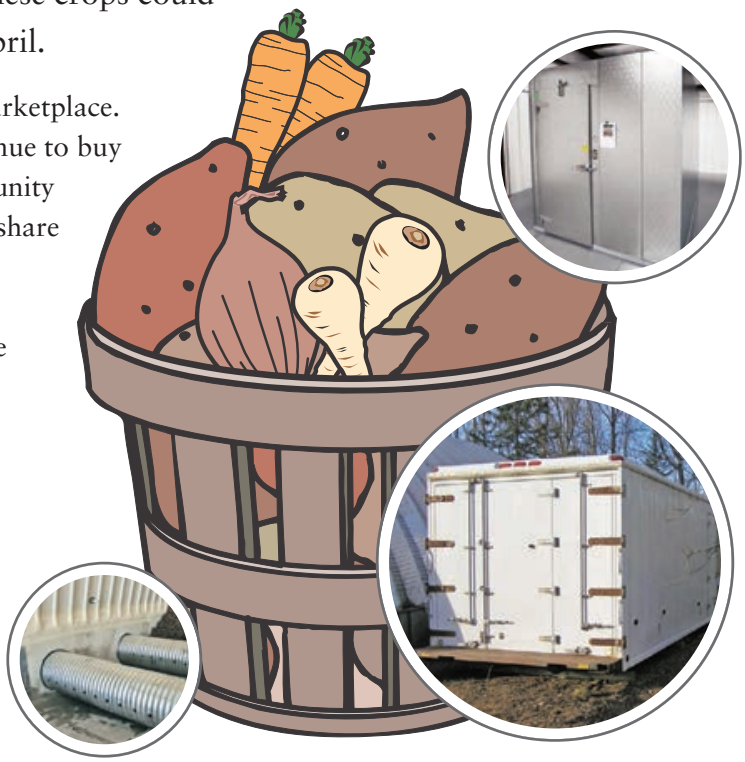
Winter crop storage can increase income and profit for growers by extending the marketing period for crops beyond harvest. Market potential for winter storage crops is large and growing. Demand for local (and organic) produce continues to outpace supply, and some food-conscious consumers are matching their diet to the seasonal availability of produce.

Many avid local food buyers lament the lack of local produce in co-ops and retail stores from December through April. Produce buyers indicate they would stock local produce if it were available.* The demand for crops such as carrots, beets, winter squash, cabbage, onions, garlic, and sweet potatoes in winter is significant and represents a largely untapped market for local growers. If growers had the appropriate storage facilities, all these crops could be successfully provided until March or April.

"Local produce could be provided successfully until March or April if growers had the appropriate storage facilities."

Retail stores represent just one portion of the marketplace. Restaurants and institutional food services continue to buy more and more local produce, and many Community Supported Agriculture (CSA) farms offer winter share boxes to their members. Collectively, the market potential for winter storage crops in the Midwest represents millions of dollars, especially given the large population bases in Kansas City, St. Louis, Detroit, Indianapolis, Chicago, Des Moines, Milwaukee, and the Twin Cities.

A December 2005 article by Laura Sayre on NewFarm.org discussed the effect of adding two, 8x12 ft cold storage rooms on Genesis



*Personal communication 2009: R. Williams, Co-op Partners; D. Lind, Viroqua Food Co-op; C. Halverson, Menomonie Food Co-op; A. Johnston, Williamson Street Grocery Co-op.

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Farm in northwestern New Jersey. They added a winter share to their CSA operation, and 140 members signed up for the 22-week winter season running from December 1 to May 1. This influx of members added about $60,000 a year to the farm's gross income.

Three growers in Wisconsin and one in Minnesota who currently grow winter storage crops report that income from these crops ranged from 16 to 25% of total annual sales. Bill Davison, formerly with the Madison Area Community Supported Agriculture Coalition (now FairShare CSA Coalition), indicates that only 4 of 42 member farms (9.5%) have facilities designed for winter storage of vegetables in 2010. The additional sales may allow small-scale growers to earn a full-time living from farming or reduce the need to work off-farm during winter.

If proper storage conditions are maintained, crops harvested in fall can be stored in bins or bulk piles for 2 to 12 months depending on the crop. Large growers may have one or more storage facilities optimized for the post-harvest requirements of a single crop. In contrast, small growers have unique issues with winter storage, because they often grow a wide variety of vegetables that have different storage requirements and varying post-harvest market life. Small growers will group crops with similar storage requirements in the same facility. For example, carrots, beets, cabbage, rutabagas, parsnips, and turnips all require the same storage conditions, about 32°F and high humidity, but potatoes

require a higher temperature of 40 to 50˚F with high humidity. Onions require about 32˚F but dry conditions, while winter squash store best at 50 to 55˚F and dry conditions. Depending on the mix of crops, growers may need two, three, or four storage rooms to meet the variety of post-harvest storage requirements.

Growers who have cold storage facilities use a wide variety of types, ranging from commercially purchased walk- or drive-in coolers to retired refrigerated truck bodies ("reefers"), rooms built inside an existing barn (often using conventional wood-framed construction methods), and root cellars buried in the ground. However, reefers, renovated rooms, and root cellars often lack cooling and ventilation controls to maintain proper storage conditions necessary to ensure produce quality. In addition, improvised solutions can increase overhead and labor costs due to inefficient use of space.

The number of storage crops, amount of each crop, time period of storage, storage requirements of each crop, and financial resources will impact the type and size of storage facility that best fits a grower's needs. Planning and siting a storage facility should also consider the movement of equipment and personnel to minimize handling and labor costs. There are some important differences between a refrigeration system for crop storage and a system used in a walk-in grocery store or beer cooler that can affect the success of storing produce.

This guide will help you plan, design, specify equipment, and operate a cold storage facility tailored to your specific requirements. The first section looks at the economics of storing fall-harvested produce. The economics of stored crops is different than that of summer-harvested produce, because the added costs of the facility, labor, shrinkage, and risk need to be factored into the selling price. Examples of the economics of several growers of different sizes are provided as a reference.

"Many growers may need two, three, or four storage rooms to meet the different storage requirements of a variety of crops."

The second section covers planning issues – how many storage rooms, how big, where they should be located, and crop storage environmental requirements.

The third section discusses different types of storage facilities, their advantages and disadvantages, and some constructions methods.

The fourth section covers environmental controls, refrigeration, humidification, and air exchange for a storage facility. There is a short section on reducing energy use for cooler operation and a discussion on material handling which is aimed at reducing excess labor costs and making sure the containers used for storage efficiently fit the cooler space. Food safety is covered briefly, because the cooler can be a source of food contamination if facilities and equipment are not kept clean and sanitized.

Examples of what other growers are doing can be valuable in formulating your own plans. Case study summaries of seven different fall-harvested crops from four different farms are provided as a reference. A brief summary is provided for each of the major storage crops grown in the Midwest with useful information that can help with planning and management. At the end is a reference section that should be useful for getting more in-depth information.

Winter storage crop economics

Growing crops for winter storage is very similar to growing for immediate sale or short-term storage. The main differences in production include selecting varieties known for their storage qualities, taking extra care to avoid disease issues that may reduce storage life, and harvesting when the crop is fully mature. None of these production factors are likely to significantly impact production costs. For the experienced grower in a northern climate, deciding to grow, store, and sell crops through the winter is mostly a consideration of markets, storage and post-harvest handling facilities, and labor availability during the months of November through April.

Having a readily available market for storage crops is the first and primary consideration. Options include winter farmers' markets, CSA programs, restaurants, schools, hospitals, retail stores, and wholesale distributors. All markets have expanded in most areas over the past decade given the demand for local produce beyond the traditional bounds of the standard "growing season." The number of farmers' markets operating through the winter is increasing; many CSA members relish the opportunity to stay connected to the source of their food; and chefs, food service professionals, and grocers increasingly see the merits of buying locally-grown products year-round.

However, the existence of a potential market does not mean that marketing and selling winter storage crops is easy nor does it guarantee that it is profitable. In addition to doing some market research, it is important to consider the additional costs and benefits of selling storage crops through the winter (Table 1).

Individual growers may recognize or experience additional costs or benefits beyond those discussed here, but these are good starting points to consider when deciding to pursue a winter storage crop enterprise.

A significant factor to consider is capitalization costs, though they will be reduced for farms that are very small-scale or have existing winter harvest capacity. Building an insulated and at least

Table 1. Costs and benefits of growing winter storage crops.

Costs	Benefits
Construction of new storage facilities	Extends use of existing storage facility assets
Increases energy costs	Expands gross sales
Increases labor costs	Provides the ability to offer year-round employment to dedicated employees
Affects quality of life by allowing less down-time for your business after a long growing season	May eliminate the need for the grower to work an off-farm winter job
Fewer available products may result in smaller average delivery volume to some customers	Helps maintain contact and sales with customers year-round
Increases expenses and administrative overhead costs	Improves cash flow during the winter

Table 2. Facilities and equipment for storage crops.

Items	Comments
Insulated storage area	There are many options for storage areas, from in-ground root cellars to large-scale coolers and everything in between.
Heated and insulated workroom	Plan to heat a room to at least 60˚F.
Tanks for soaking roots	Soaking loosens dirt clinging to roots and makes subsequent cleaning easier.
Miscellaneous post-harvest equipment	These items include regular and roller tables, scales, packing equipment, and various other items.
Hand truck, pallet jack, forklift or skid-steer loader	Most winter storage crops are heavy. It is best to move them using a hand truck, pallet jack, or forklift rather than carrying them by hand. This equipment requires a flat, concrete floor in the cooler and work area.
Harvest bins, pallet bins, and totes	While some growers store crops like carrots or potatoes in bulk piles, containers are generally more effective and efficient for small to mid-scale growing operations.
Brush, batch, or barrel washer	When growing winter crops in significant volume, brush or barrel washers provide an efficient and effective way to clean the harvest.
Mechanical harvester	These tools include carrot, beet, and parsnip lifters; potato and onion diggers; conveyers for assisting with harvest of cabbage and winter squash; and other devices.

minimally heated facility is a virtual necessity in northern climates. Table 2 lists various facilities and equipment that might be required depending on the size of the growing operation.

The list in Table 2 is oriented toward larger operations, but even smaller-scale growers will need adequate storage facilities and an efficient means for handling and washing produce. All facilities will also need to be heated to allow employees to work comfortably and to avoid the risk of freezing produce or water lines. Small operations can use a hand truck in the place of a pallet jack for moving boxes or totes instead of large bins. A hands-free wash station in which a foot peddle or a motion sensor turns on water can replace barrel or brush washers. Keep in mind that the amount of produce that can be effectively and profitably processed by hand is limited.

Mechanical harvesters, vegetable washing equipment, and sorting lines can improve efficiency for many operations, but they also increase capital costs.

The cost of coolers depends on the size, wall thickness, and other options such as doors and floors. The cost of a new cooler with refrigeration ranges from approximately $5,200 for a cooler measuring 6 ft wide x 8 ft long x 8 ft tall (5.33 ft wide x 7.33 ft long x 7.66 ft high inside) to approximately $23,000 for a cooler measuring 20 ft wide x 30 ft long x 12 ft tall (19.33 ft wide x 29.33 ft long x 11.66 ft high inside). This translates to a cost of $40 to $132 per square foot ($ft^2$) of floor area or a cost of $3.50 to $17.25 per cubic foot ($ft^3$) of volume.

Figures 1 and 2 provide an approximate value of the cost (per square foot and per cubic foot) of a cooler with refrigeration but without a floor. Costs in addition to this would include a concrete floor, freight for the cooler materials, installation, light fixtures, humidifier, and any racking (shelving) desired. When creating a budget for a cooler, check the cost based on both square footage and cubic volume, and use the greater value.

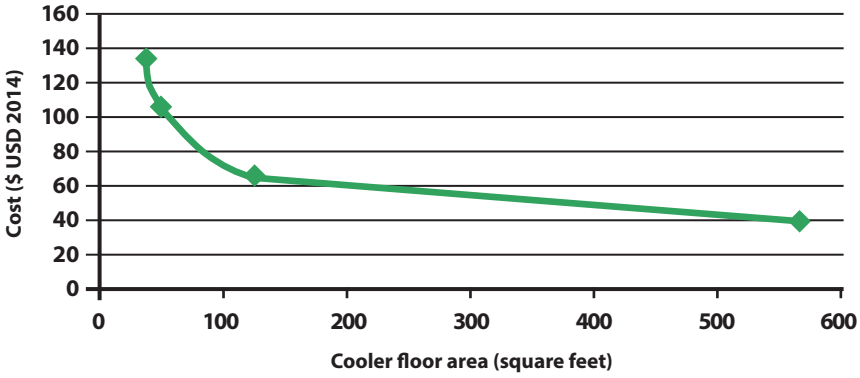

Figure 1. Cooler cost per square foot.

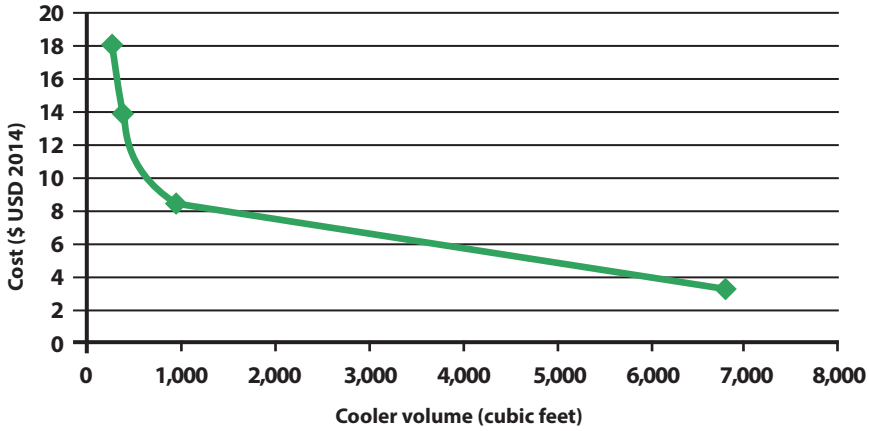

Figure 2. Cooler cost per cubic foot.

Another important cost for storage crops is "shrinkage." Shrinkage is the amount of stored produce that is not fit for market. For storage crops, this is not only the amount of the harvest that is culled based on quality characteristics including size, shape, and uniformity, which will be similar to produce harvested for immediate sales, but also the amount of produce that spoils during storage or needs to be trimmed. The amount of shrinkage can vary widely based on crop variety, production practices, crop condition at harvest, harvest and post-harvest handling practices, storage conditions, and duration of storage. See Table 3 for the relative amounts of shrinkage across different crops reported by Wisconsin and Minnesota producers.

Storage crops will have added costs over products sold shortly after harvest, so it is logical that the price you get for those products should reflect the additional costs. Anecdotal evidence suggests that labor, post-harvest losses, and storage costs for storing and marketing vegetables through the winter may result in a 20% increase in cost. If winter sales are a new enterprise for you, there may also be marketing and delivery costs to include in your overall budget. Whether the market can bear a higher price should be considered when developing a marketing plan for winter storage crops.

In many cases, producers are able to charge a higher price at winter farmers' markets, because there is less supply or competition in the marketplace. Wholesale accounts may be more resistant to higher prices, though buyers at restaurants or retail stores with a strong preference for local produce or strong personal relationships with

Table 3. Amount of shrinkage for common storage crops.

Crop	Crop Loss (%)	Source of shrinkage
Carrots	3 - 10	Mostly culls based on size and shape
Beets	5 - 10	Black spot and rot
Winter squash	20 - 40	Rot and disease; not selling within the typical storage time
Onions	20 - 30	Spoilage and disease
Cabbage	10 - 40	Spoilage and disease
Potatoes	6 - 12	Soft rot, scabbing, knobbing, and greening

Source: John Hendrickson, 2013 survey of six growers.

farm suppliers may be able to absorb or pass along these added costs to the final consumer.

When determining an acceptable price and measuring profitability, a grower should factor in all costs of growing, harvesting, washing, storing, packaging, marketing, selling, and delivering their goods to market, in addition to general overhead expenses. One useful tool for documenting costs and tracking profitability is Veggie Compass (www.veggiecompass.com), a spreadsheet tool developed at the University of Wisconsin-Madison in partnership with growers. When using Veggie Compass to assess the profitability of winter storage crops, it is best to treat each stored crop as a separate product rather than including them with the same crop sold fresh during the growing season. Due to handling and storage costs, storage crops may require a higher price in order to be profitable.

As explained, one very important consideration in developing facilities for winter storage crops is assuring proper temperature and humidity conditions. Proper environmental control is essential to maintain optimal quality, which lengthens storage life, reduces income loss due to shrinkage, and directly improves the bottom line. Nearly all winter storage crops are sold by the pound, as opposed to bunches or by volume. Improper storage conditions will cause excessive moisture loss, reducing the weight of the produce and, in turn, the revenue from its sale. A profitable winter storage crop enterprise should factor in the necessary capital improvements to ensure near optimal storage conditions so that the crop and the profits do not shrink as the result of moisture loss.

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The overall profitability of storage crops obviously depends on a great many factors and is likely to vary from farm to farm depending on markets, pricing, yields, scale of operation, labor, and

other variables. Table 4 provides profiles of several farms in Wisconsin and Minnesota.

Table 4 suggests that on the small-scale farm where the owner might be doing all the additional work of marketing, packaging, and delivering, the costs of winter sales might be very modest compared to the additional gross sales generated. On larger farms, winter sales will likely demand supplemental hired labor that brings with it the necessity of management, payroll expenses, and overhead. Selling high volumes will also demand more efficient means to handle the product, increasing capital investment costs.

These examples also suggest that the capital costs of a modestly sized additional storage unit would be recovered relatively quickly based on gross sales potential. However, it is a mistake to confuse how quickly the cost of a capital investment can be recovered with how profitable a winter storage crop enterprise might be on an individual farm. To determine the latter, one needs to create a complete enterprise budget and then use record-keeping to measure the performance of the enterprise over time.

Along with traditional hoop houses, winter storage crops offer another option for extending the growing, marketing, and selling season. With planning, preparation, appropriate infrastructure, available markets, and management, winter storage crops can be an important component of a fresh market farm business.

Table 4. Profiles of example farms selling storage crops.

	Farm A	Farm B	Farm C	Farm D
Cubic feet of storage space	812	6,000	17,374	22,400
Type of facility	Root cellar, room attached to a house	4 storage rooms	3 storage rooms	2 storage rooms
Crops	Roots, alliums, squash, cabbage, sweet potatoes	Roots, alliums, squash, cabbage	Roots, alliums, squash, cabbage, sweet potatoes	Cabbage, carrots, butternut
Winter labor	Owner (2-4 hrs/wk)	Owner + 1 part-time employee (30 hrs/wk)	Owner + 5.5 employees (part-time and full-time) (80-90 hrs/wk)	Owner + 8 employees (part-time and full-time) (280 hrs/wk)
Major market (Secondary market)	**CSA** (Direct wholesale)	**Direct Wholesale** (CSA and farmers' markets)	**Direct Wholesale** (Distributor and CSA)	**Direct Wholesale** (CSA)
Gross sales	$14,400	$85,000	$136,000	$250,000
Gross sales per cubic foot	$18	$14	$8	$11
Estimated annual capital cost*	$817	$3,317	$5,081	$5,992

*Assumes 15-year storage facility life, 7% return on investment.

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