A PNW Extension Publication

Winter Vegetable Production

on Small Farms and Gardens West of the Cascades

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Cover: Photo of 'Brilliant Lights' chard (top) by Anna Ashby, photo of Laura Masterson of 47th Ave Farm (bottom left) by Lane Selman and photo of Polly Gottesman, James Just and their dog Jasper of Pumpkin Ridge Gardens (bottom right) by Carrie Fay Amarp.

Introduction

The mild climate west of the Cascades allows farmers and gardeners to grow many winter-hardy crops in the field for winter and spring harvest. A wide range of alliums, leafy greens, brassicas and root crops do well. For gardeners, these winter vegetables provide fresh, nutritious, homegrown produce from November to April. For farmers, winter vegetable production can provide cash flow outside the normal summer cropping season, more consistent work for employees and year-round relationships with direct-market customers.

Farmers may offer year-round or winter community supported agriculture subscriptions, or sell into co-ops, restaurants or year-round farmers markets. Some seed companies and produce distributors have supported winter vegetable production in western Oregon and Washington for many years. Buyers and distributors who primarily source produce nationally or internationally are often not as receptive to locally grown winter vegetables. Western Oregon and Washington farmers typically sell their winter vegetables directly to local customers.

Winter weather, with occasional cold snaps, heavy rain, mud and reduced sunlight, makes raising and harvesting winter vegetables challenging. Good site selection, field preparation, crop and cultivar selection, planting and harvest timing, irrigation and pest management all contribute to your success. Although little research has been done on winter vegetable production in the Pacific Northwest, we based the recommendations in this publication on insights from local farmers, seed company representatives and Extension faculty. For each topic, we provide references for more detail, and the "Resources" section lists additional resources.

Photo: Neil Bell, © Oregon State University
Brassica leafy greens like these at Mustard Seed Farms are a mainstay of winter vegetables. Notice the ground cover provided by the volunteer chickweed between the beds.

Chapter 1

Choosing a location

Many sites west of the Cascades are suitable for winter vegetable production. Look for sites with full sun and well-drained soil, which are essential for success. Flat sites and south-facing slopes generally get the most sun. To check whether your site is sunny enough in winter and spring you can map your location with a sun path chart. Also, consider shade cast by tall trees or buildings.

Soil

Soils with good structure and adequate drainage can absorb rain and resist puddling and standing water. Well-drained soils can reduce mud during harvest, and are sometimes dry enough to cultivate after winter dry spells. The winter before you plant, scout potential sites after heavy rain to check for water erosion and standing water, and to see if the site is accessible to people and equipment during wet weather (Figure 1). Floodwater from nearby rivers, lakes or streams can cause complete crop loss. If the edible portion of your crops comes into contact with floodwater, it is considered adulterated food by the FDA and should not be sold or eaten. See *Food Safety for Flooded Farms* from the Product Safety Alliance for more information. The U.S. Department of Agriculture's Natural Resources Conservation Service's online Web Soil Survey identifies the soil type, drainage class and flooding or ponding frequency of a field. The NRCS SoilWeb app for Android phones and iPhones helps you identify soil types in the field.

In gardens with poorly drained soils, raised beds can improve drainage (Figure 2). However, raised beds can also make crops more susceptible to cold injury. For more information on building and using raised beds see *Raised Bed Gardening* (FS 270).

Climate and weather

The maritime climate of the valleys and coastal regions of western Oregon and Washington has heavy winter precipitation and relatively mild temperatures that are often above freezing in winter. These conditions make winter vegetable production possible in the field.

USDA hardiness zones show the average low temperature on the coldest night in the winter. The lowest winter temperatures determine whether a crop can survive over the winter in your area without protection. Different hardiness zones are color-coded. The USDA map is online in a static or interactive format. The interactive version allows for navigation around the map to confirm specific hardiness zones (see Figure 3).

Photo: Heather Stoven, © Oregon State University
Figure 1. Low-lying areas of the field can accumulate standing water. Choose fields with good drainage. Planting in raised beds or in berms can help keep vegetables from sitting in water.

The USDA updated its hardiness zones in 2012. Table 2 provides more information on the cold hardiness of different winter vegetables.

About 75% of annual precipitation typically occurs from October to March. The Cascade and Olympic mountain ranges dramatically affect rainfall and temperature patterns in the region. Ocean moisture arrives as rain or snow. As weather systems move east over the mountains, they cause heavy winter rain and occasional snow west of the mountains and drier "rain shadows" east of the Cascade and Olympic mountain ranges. Figure 4 shows the average annual precipitation from 1981–2010.

You can find historical weather data such as high and low temperature and precipitation at the National Oceanic and Atmospheric Administration or other weather-forecasting websites. You can also download local weather station data from the Agrimet website. Agrimet allows you to view historical data on a site's precipitation, air temperatures, soil temperatures, degree-days, wind speeds and more. This data can help you choose a site or crops and is particularly helpful in developing a commercial winter vegetable enterprise.

Keep an eye on the weather forecast to anticipate weather-related challenges. Precautions, such as installing row covers, might be needed during cold spells. See the "Cold weather protection" section of this publication for more information.

Temperature and microclimates

Most winter vegetables are established in the summer or early fall. They don't grow much from November through February, and each crop responds differently to winter temperatures.

Plants are ectotherms. Their metabolism doesn't maintain consistent body temperatures like endotherms (warm-blooded animals, for example). As a result, the plant temperature is always close to the ambient air temperature. Plants develop and grow more quickly at warm temperatures (70–90 degrees Fahrenheit) compared to cold

Photo: Heather Stoven, © Oregon State University
Figure 2. Raised beds can help improve soil drainage in wet areas.

Figure 3. This image shows different climate zones west of the Cascades from the interactive USDA Plant Hardiness Zone Map.

Average Annual Extreme Minimum Temperature 1976-2005

- 4a (-30 to -25 °F)
- 4b (-25 to -20 °F)
- 5a (-20 to -15 °F)
- 5b (-15 to -10 °F)
- 6a (-10 to -5 °F)
- 6b (-5 to 0 °F)
- 7a (0 to 5 °F)
- 7b (5 to 10 °F)
- 8a (10 to 15 °F)
- 8b (15 to 20 °F)
- 9a (20 to 25 °F)
- 9b (25 to 30 °F)

temperatures (32–50 degrees, assuming they have enough water and nutrients.

Degree-days or heat units measure temperature accumulation over time. They usually predict crop growth stages more accurately than time alone. Different crops and cultivars develop at different rates depending on their response to degree-days and their base temperature for growth. There are no degree-day models available for local winter vegetable varieties, but the concept of degree-days (time, temperature and base temperatures) helps us understand crop development rates. See *Vegetable Degree-Day Models: An Introduction for Farmers and Gardeners* (EM 9305) for more information.

Microclimates also play a role with winter vegetables. When warm air rises, cold air flows downhill, so gentle slopes allow cold air to drain away from the slope and settle below. Avoid planting at the bottom of hills or slopes where colder air may collect. South- or west-facing slopes receive the most heat in winter. Sites within 20 feet of a structure may have a warmer microclimate than those farther away.

Choose a sheltered site. Winter winds can damage crops and make harvest work more difficult. You can plant windbreaks to protect crops and improve working conditions, however. Trellises that support summer vining plants can be left in the field or garden as a windbreak.

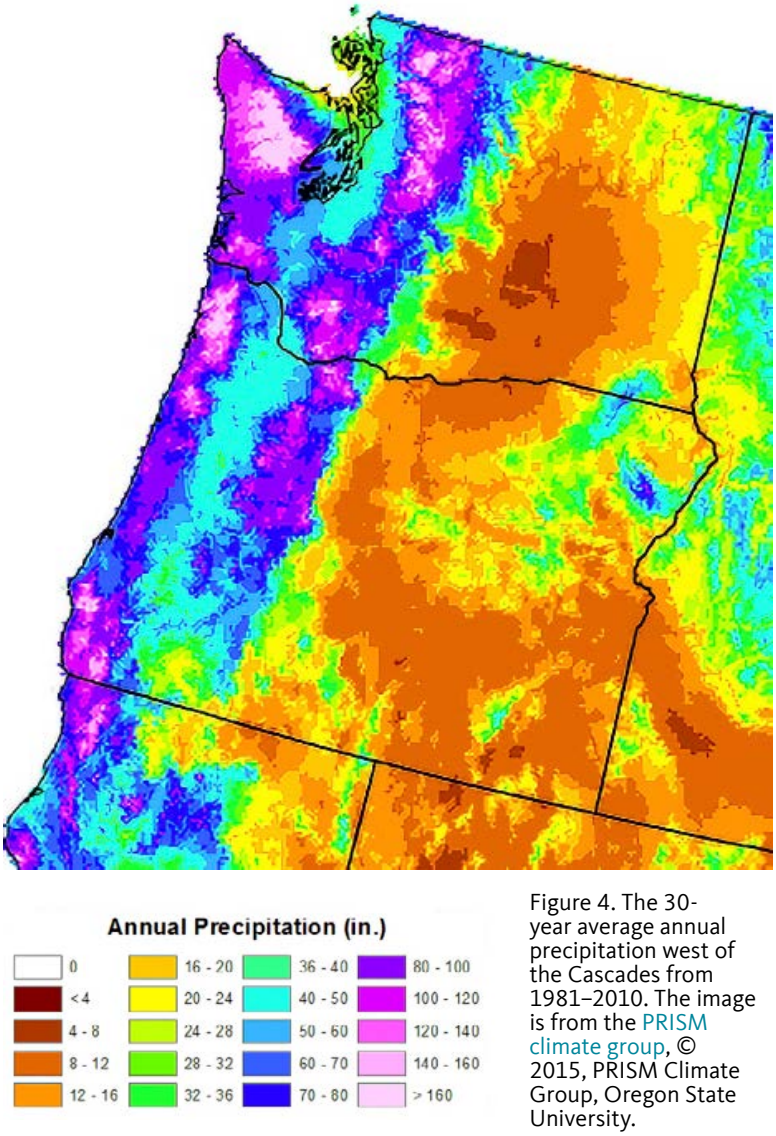


Figure 4. The 30-year average annual precipitation west of the Cascades from 1981–2010. The image is from the PRISM climate group, © 2015, PRISM Climate Group, Oregon State University.

Chapter 2

Field management

This chapter provides general information on field management that is applicable to all winter vegetables. More crop-specific growing information is in Chapter 3: Crop Management.

People

Harvesting winter vegetables can be cold, wet work. Avoid the worst weather and make sure you and your crew wear raingear and waterproof insulated gloves and boots. Harvesting in wet, muddy conditions can damage soil structure, especially in fine-textured silty or clayey soils, and leave your crop contaminated with mud. Cleaning muddy vegetables is time-consuming. Use solid bottom harvest containers and avoid placing slotted harvest containers on muddy ground. Cover crops can reduce mud contamination by providing more ground cover. Consider planting fewer beds and increasing paths or roadways to improve access to winter vegetables in wet conditions. Designate plenty of "landing sites" to drop off harvest totes. These sites reduce walking distance, and can be used for field trimming and cleaning harvested vegetables before storage.

Soil and nutrient management

Soil testing

Regular soil testing and interpretation help you manage soil acidity and nutrients. Anticipate pH or nutrient management problems rather than trying to respond to them quickly in an emergency. By the time nutrient deficiencies appear, some crop quality and yield have already been lost.

Basic soil sampling guidelines for routine soil analysis are available in *A Guide to Collecting Soil Samples for Farms and Gardens* (EC 628). Fields or gardens with different soil textures or management histories may have different nutrient requirements. If this is true for your property, divide your fields into different management units that reflect these differences and sample each unit separately.

This approach is described in *Monitoring Soil Nutrients Using a Management Unit Approach* (PNW 570). A diverse farm with a history of soil management practices that differ between field sections may benefit from a special approach to sampling. Grouping samples from smaller zones with a known management history within your larger management units may provide more reliable results. This approach is described in detail in the Washington State University publication *Soil Testing: A Guide for Farms with Diverse Vegetable Crops* (EM 050E).

Soil organic matter

Soil organic matter can release plant nutrients, buffer soil pH, improve water infiltration and drainage, and improve the ability of soil to store water during droughts. Increasing soil organic matter typically improves your soil.

Routine soil test reports show the percent of soil organic matter. This is an estimate of total soil organic matter. Cover crops and bulk organic amendments increase biologically active organic matter in soil, releasing nutrients and providing other benefits to farms and gardens.

The biologically active portion is usually a small fraction of the total organic matter and is difficult to quantify. However, if you are using these types of amendments, the need for nitrogen and other fertilizers is likely reduced (see nitrogen below).

For more information, see *Soil Organic Matter as a Soil Health Indicator: Sampling, Testing and Interpretation* (EM 9251).

Soil pH

Soil pH doesn't change quickly. In most soils west of the Cascades, soil pH gradually drops over time. If left unmanaged, it can be around 5.5. Rainfall and nitrogen fertilizer tend to cause soil pH to drop. Soil organic matter buffers pH, and fields with high organic matter levels may not need to be amended with lime as often. Gardens where large amounts of compost is added annually will likely have a soil pH greater than 6.0.

Table 1. Recommended minimum pH for some winter vegetable crops

Crop	Recommended minimum soil pH
Carrots	5.6
Garlic	6.5
Heading brassicas[1]	6.3
Onions	6.0 to 6.5
Radish	6.0
Spinach	6.0 to 6.5
Table beets	5.8
Turnips	5.8-6.0

Adapted from Table 9 in the *Soil Acidity in Oregon: Understanding and Using Concepts for Crop Production* (EM 9061).
[1]For brassicas grown in soils infested with P*lasmadiophora brassicae* (clubroot), liming to a higher pH is often used to control disease.

Lime application rates are determined by soil testing and lime requirement tests, such as the Shoemaker, MacLean and Pratt (SMP) test, and the Sakora buffer test which is replacing the SMP. For more information, see *Applying Lime to Raise Soil pH for Crop Production (Western Oregon)* (EM 9057), but use the *Updated Lime Requirement Recommendations for Oregon* to interpret the SMP and Sakora buffer tests and ask your lab which lime requirement test they use.

Brassicas are susceptible to the disease clubroot (*Plasmodiophora brassicae*) which thrives at pH levels below 6.5. Apply lime to increase pH above 7 to manage this disease. For more information about clubroot, see the "Heading brassicas" section.

General nutrient management

The following nutrient management publications are updated based on new research and provide applicable information. *Soil Fertility in Organic Systems: A Guide for Gardeners and Small Acreage Farmers* (PNW 646) discusses types of fertilizers, nutrient availability and introduces organic nutrient management.

Nutrient Management for Sustainable Vegetable Cropping Systems in Western Oregon (EM 9165) explains how to interpret soil test results and determine fertilizer rates and nutrients needed for a wide range of vegetable crops west of the Cascades. The publication emphasizes summer vegetables, but nutrient management for winter vegetables is similar for soil pH, phosphorus, potassium and most other nutrients except nitrogen.

Manure, compost and other bulk amendments increase soil health and fertility. If repeatedly over-applied, they can cause excessive soil nutrient levels (nitrogen and phosphorus, for example) and increase water contamination risk. If using these types of amendments, *Fertilizing with Manure and Other Organic Amendments* (PNW 533) can help determine application rates based on amendment nutrient content.

Nitrogen

Nitrogen fertilizer is an expensive input, especially for organic farmers, and is often needed in the largest quantity. Your crop and field management history influence optimum nitrogen application rates for winter vegetables.

For winter vegetables that mature in the fall or early winter and put on little to no additional growth in the spring, follow the approach described on pages 15–20 of *Nutrient Management for Sustainable Vegetable Cropping Systems in Western Oregon* (EM 9165). Winter vegetables that continue to grow in the spring may benefit from supplemental nitrogen fertilizer in early spring when soil nitrate levels are low. Spring nitrogen applications benefit many heading brassicas and leafy greens, such as collards and kale.

Repeated applications of organic amendments such as compost, leaf mulch, manure and robust cover crops can increase the amount of nitrogen released by soil organic matter. High biomass cover crops with legumes in the mix, various livestock manures and other bulk organic amendments can provide significant amounts of plant-available nitrogen for the following crop. See *Estimating Plant-Available Nitrogen Release from Cover Crops* (PNW 636) to learn how to predict the nitrogen fertilizer value of your cover crops. If you estimate nitrogen release from these nonfertilizer sources (that is, soil organic matter, bulk amendments and cover crops), you can often reduce your nitrogen fertilizer application rates. This can save money while protecting the environment.

Nitrogen monitoring is useful for winter vegetables, especially in fields with high organic matter and other nonfertilizer nitrogen sources. In crops planted after mid-June, pre-plant soil nitrate tests can determine nitrogen rates during bed preparation. For spring-planted crops, midseason nitrate-N monitoring (at four to five true leaves, for example) can detect potential deficiencies later in the season. Soil nitrate monitoring can help you improve nitrogen management for all vegetables on your farm, not just winter vegetables. For more information, see *Soil Nitrate Testing for Willamette Valley Vegetable Production* (EM 9221).

Irrigation

Winter vegetables are planted in the summer and need consistent irrigation during establishment. Most winter vegetables are not heat or drought tolerant, and they are sometimes transplanted at the hottest and driest time of the year in the Pacific Northwest. Avoid drought stress during establishment. West of the Cascades, winter vegetables don't need irrigation after fall rains begin, which usually occur from mid-September to mid-October.

Cold weather protection

Row covers are made from lightweight, spun-bonded polyester fabric and are sometimes used to protect field-grown winter vegetables from cold weather. They come in varying thicknesses. Thicker covers provide more temperature protection but less light transmission than thinner row covers. Medium weight covers (0.50–0.55 ounces per square yard) can provide up to 4°F of protection with 85% light transmission. Heavyweight covers (0.90–2.0 ounces per square yard) can provide 4–8°F of protection with 30% to 50% light transmission.

Row cover material is breathable, permeable to moisture and can be used through the winter season to add protection. It can be placed lightly over the crop and held in place with staples, soil or sandbags as a floating row cover to protect crops from low temperatures (Figure 5). Be aware that floating row covers can stick to the crop if freezing temperatures follow precipitation. See Washington State University's *How to Install a Floating Row Cover* (FS 089E) for more information.

Small hoops can be used to create a low tunnel a few inches over the crop and reduce the risk of row covers sticking to the crop (Figure 6). For more information *see Low Tunnels for Season Extension in Oregon: Design, Construction and Costs* (EM 9333).

In gardens, cloches can be installed as more permanent structures. They are described in *How to Build Your Own Raised-Bed Cloche* (EC 1627). On warm, sunny days, heat can build up in cloches or under row covers and stress crops. They can also create a good habitat for insects, diseases and weeds. Monitor them and ventilate as needed.

Crop rotation

Rotating different crops helps reduce soilborne diseases and manage weeds, nutrients and some arthropod pests. When planning rotations, consider which factors can be improved by crop rotation and study the pest lifecycle or nutrient cycle relevant to those objectives. Pay special attention to the biology of soilborne diseases in your farm or garden.

Rotations can vary depending on the crop, pest biology and nutrient cycling. Brassicas are important winter crops, and they nicely illustrate crop rotation considerations. Many vegetable farms and gardens already have a lot of Brassicas in their summer rotation, so pest prevention, monitoring and management are important. A short rotation between Brassica crops increases the risk of clubroot (*Plasmadiophora brassicae*). Winter brassicas are transplanted in July or August and are easy to cultivate. For this reason, they can help to manage summer weeds after difficult-to-cultivate crops where weeds may have recently gone to seed. Brassicas also take up a lot of nitrogen, so they can utilize residual nitrogen left over from a previous crop or nitrogen mineralized by a soil with high organic matter content.

It is difficult to incorporate all potential considerations in rotation decisions. Start by focusing on factors of greatest concern at a particular site. For more information about crop rotation planning, see the USDA SARE book *Crop Rotation on Organic Farms: A Planning Manual.*

Photo: Neil Bell, © Oregon State University
Figure 5. Floating row cover on winter cabbage.

Photo: Heather Stoven, © Oregon State University
Figure 6. Row covers can be placed over hoops to form a low tunnel, which keeps the fabric off the foliage.

Cover crops

Cover crops (Figure 7) protect soil from erosion, improve soil health, compete with weeds and provide various other benefits. The wet and mild winter climate in the maritime Pacific Northwest is well-suited to cover crops, and winter vegetables can benefit from their use. When cover crops provide soil cover, they can help reduce soil compaction and mud contamination during harvest.

Consider interseeding or relay seeding cover crops into late fall and winter vegetables (Figure 41). The best timing for relay seeding depends on the crop and production system but is typically done at the last mechanical weed cultivation and before crops shade the soil surface and inhibit cover crop establishment. Overwintered annual cover crops establish in summer and fall, cover the soil over the winter, grow vigorously from March through May and produce flowers in May or June. If you interseed during hot and dry weather,

Photo: Heather Stoven, © Oregon State University
Figure 7. Cover crops protect soil and reduce mud contamination of crops. Legumes like the crimson clover shown here provide plant-available nitrogen for the following crop.

overhead irrigation and good seed to soil contact will improve establishment. Your soil benefits from large cover crops (such as those with high biomass when terminated), and beneficial insects (such as natural enemies and pollinators) can benefit from flowering cover crops. For information about nitrogen contributions from legume cover crops, see the "Nitrogen" section above. For general information about cover crops, see the USDA SARE book *Managing Cover Crops Profitably (3rd Edition)*.

General pest management

To prevent, monitor and manage pests you have to identify them correctly, and learn about their biology and available management strategies. This section describes some pests that damage many different winter vegetables. Individual crop management sections discuss more host-specific diseases and pests, and some crop-specific weed management considerations. The disease sections discuss fungi, bacteria, viruses and nematodes. The pest sections include pests in the Kingdom Animalia, except for nematodes.

The *Pacific Northwest Handbooks for Insect, Disease and Weed Management* describe pests, their lifecycles and types of crop damage, and explain cultural, chemical and biological control options, including pesticide information. Always apply pesticides according to the label instructions. The label provides safety precautions to protect you, others and the environment. Read the label before buying or opening the container. Reread before mixing, storing or throwing the product away.

Local Extension services and plant diagnostic clinics, such as the OSU Plant Clinic and WSU Plant Pest Diagnostic Clinic, can help you diagnose unfamiliar plant health problems.

Diseases

Wet weather and saturated soils are favorable conditions for many winter vegetable diseases. Management practices include clean seed or planting material, crop rotations that reduce disease pressure, and crop monitoring and treatment as needed.

Some plant pathogens are introduced on seeds and can be difficult to manage once introduced. Using clean seed prevents these problems, but vegetable seeds are not universally tested for seedborne diseases. Most seed treatments are not allowed in organic agriculture, but hot-water seed treatment is often an effective alternative. Organic Seed Treatment and Coatings from eOrganic and Washington State University explains seed priming, pelleting and some organically allowed seed treatments, including a table of time and temperature requirements for hot-water treatment of different vegetable seeds. ODA Black Leg Rule and Small-Scale Hot Water Seed Treatment explores low-cost and reliable hot-water seed treatments developed by Wild Garden Seed and High Mowing Organic Seeds. These techniques are practical for small-scale farmers and gardeners.

Root-knot nematodes

Meloidogyne hapla can infect most dicotyledonous vegetables, but damage to root crops is most severe because roots can become forked and malformed,

and large galls can develop. A few years of rotation into cereals, sweet corn or other nonhost plants can dramatically reduce populations if dicotyledonous (broadleaf) weeds are controlled. If you have a root-knot nematode hot spot, you can rotate to monocotyledonous crops for a few years, then sample your soil and submit to the OSU Nematode Testing Service to check whether populations are low enough to return to susceptible crops. For more information, see Carrot – Root-knot Nematode in the PNW Plant Disease handbook and the University of California website *Meloidogyne hapla.*

White mold

Sclerotinia sclerotiorum is a soilborne fungus that can damage many vegetables. It develops distinct white mold on plants and plant debris, and forms small black overwintering structures called sclerotia in the soil. When temperatures rise in the spring, the sclerotia eject spores into the air, and most land nearby unless carried by wind. Winter vegetable hosts include plants in the *Amaryllidaceae* (such as onions, garlic and chives), *Brassicaceae* (cabbage, kale, broccoli, cauliflower and mustard greens), *Fabaceae* (fava beans) and *Apiaceae* (carrots, parsnips, celery and parsley) families. Its host range also includes many summer-grown vegetables, such as tomato, potato, pepper, cucumber, zucchini, squash, peas, snap beans and sunflowers. For a more complete list of hosts, see Plants Susceptible to Sclerotinia sclerotiorum.

Avoid growing winter vegetables in fields heavily affected by white mold. Crop rotation isn't usually a management option on vegetable farms because of the fungi's broad host range and ability to survive for years in the soil, but rotation to nonhost crops such as sweet corn and grains may reduce the amount of pathogen in the field over time. Increasing spacing to allow good airflow while avoiding excess nitrogen fertilizer and dense canopies can reduce disease risk. Organic pesticide options are limited; Contans™ is an organically approved biological fungicide (*Coniothyrium minitans*) that can be effective. For more information see What is Contans and how can it be used in western Oregon to control white mold? White rot is a more host-specific disease of alliums that is caused by a different pathogen (*S. cepivorum*), and is discussed in the allium crops section.

For more information about white mold, see the *Pacific Northwest Pest Management Handbook* section for Kale – Sclerotinia Stem Rot (White Mold).

Refer to the "Crop management" section for information about more host-specific diseases.

Pests

Garden symphylans

Garden symphylans (*Scutigerella immaculata*) is a serious pest of brassicas, leafy greens, alliums and root crops. Fava beans appear to be relatively tolerant, but are also hosts. Symphylan populations can be monitored with potato traps and reduced by rotating to potatoes or with intensive tillage immediately before planting. For more information on biology, monitoring and management, see Biology and Control of the Garden Symphylan, and the ATTRA publication *Symphylans: Soil Pest Management Options*.

Wireworms

Wireworms are the larvae of various species of click beetles; native and invasive species are present in

Photo: Heather Stoven, © Oregon State University
Figure 8. Slugs are a major pest of winter vegetables. Their feeding causes shredding and holes between veins in the foliage.

Photo: Heidi Noordijk, © Oregon State University
Figure 9. Slug eggs are laid in clusters and are typically about a quarter-inch in diameter. They are often transparent, but can also be golden or white in color depending on the species.

the PNW. Adults don't cause crop damage, but the larvae feed on seeds, roots and tubers and can live for two to five years. They can attack a wide range of crops, including winter vegetables, and root crops can suffer extensive damage. See Vegetable Crop Pests – Wireworm and *Wireworm: Biology and Nonchemical Management in Potatoes in the Pacific Northwest* (PNW 607) for information on wireworm biology, monitoring techniques and a range of management strategies.

Slugs

Slugs can be a major pest of winter vegetables. They are active when relative humidity approaches 100% and temperatures are 38°–88°F. Slug damage can be distinguished from other pests by the presence of slime trails. Damaged roots have small, shallow pits, leaves are damaged by holes between veins. Slug damage can cause 'window pane' holes on leaves, complete holes and shredding (Figures 8 and 9). Recent damage on leaves can often be distinguished from holes caused by chewing insects by the wedge-shaped edges of the holes that are visible with a hand lens. The wedge shape is caused by their rasping mouthparts; slugs feed by scraping at their food. Several species can be important in the Pacific Northwest, including *Deroceras reticulatum*, *Arion rufus*, *A. Circumscriptus*, *A. intermedius*, *A. subfuscus*, *Milax gagates*, *Limax maximus*, *Deroceras laeve* and *Prophysaon andersonii*.

Management practices include slug and snail baits (such as iron phosphate), barriers, cultivation and biological control. Birds, ground beetles and rove beetles are predators. Some parasitic nematodes (*Phasmarhabditis hermaphrodita* for example) can kill slugs and snails. For more information, see Slug Control.

Photo: Heather Stoven, © Oregon State University
Figure 10. Rodents feed on winter vegetables and leave holes or mounds in fields. Voles damaged this carrot crop.

Winter cutworm

Noctua pronuba was introduced to the Pacific Northwest in the early 2000s and recently has been reported in high numbers. They have a broad host range, including many important local crops, and have the potential to become a serious pest. Winter vegetable hosts include beet, carrot, brassicas, potato and chard. Females can lay up to 2,000 eggs. The larvae cause crop damage and are active from September to March. They sometimes move in large numbers, clipping, mowing or notching foliage. Tillage and weed control can reduce pest pressure. Moths and larvae are mostly nocturnal. For more information, see Grass seed – Winter Cutworm and Winter Cutworm: A New Pest Threat in Oregon.

Rodents

Rodents can cause significant damage to winter vegetables. Common rodent pests include pocket gophers (*Thomomys* spp.), voles (*Microtus* spp.) and ground squirrels (*Otospermophilus* spp.). Winter vegetables are susceptible to damage because they provide rodents valuable nutrition over the winter. For example, chicory and radicchio seem to be especially attractive to pocket gophers and voles. Root crops are another rodent favorite (Figure 10), and other winter vegetables can also be damaged. Management strategies depend on the rodent and include trapping, baits, habitat modification, deep tillage to disrupt their tunnels and nests and predators such as raptors and coyotes.

For information on pocket gophers, voles and ground squirrels, see these University of California publications:

- Pocket gophers
- Voles (Meadow mice)
- Ground Squirrel

Deer

Deer feed on and trample winter vegetables, sometimes causing severe crop damage. Their manure can also increase the risk of foodborne illness. They normally feed in late evening and early morning. This University of California publication *Deer* discusses some management options for mule deer, *Odocoileus hemionus columbianus*, which is common west of the Cascades.

Weeds

Weed management is critical during crop establishment in summer and early fall. After fall rains start, there are fewer opportunities to mechanically control weeds. Weeds that go to seed in fields or gardens will increase weed pressure in future years.

Many winter vegetables compete well with winter weeds. Some weeds can serve as a useful ground cover for mud management during harvest and act like a cover

crop to protect the soil from erosion. The exception is with alliums, and slow-growing root crops like parsnips and carrots.

These crops are less competitive with winter weeds due to their shallow root system and open crop canopy, which allows light to penetrate and promote weed growth. Their close spacing also makes cultivation difficult. Weeds can also damage the shape of these crops and interfere with harvest. Plant alliums and root crops in fields with low weed pressure.

The stale seedbed technique reduces weed seeds and helps prevent weeds after the crop is established. The technique consists of four steps:

1. Prepare the seedbed and irrigate if the soil is dry.
2. Allow time for weed seedlings to emerge.
3. Kill the seedlings without disturbing the soil below about 2 inches.
4. Plant the crop.

Steps 2 and 3 can be repeated if time allows. In some slow-germinating, direct-seeded crops (carrots and parsnips, for instance) step 3 can be used after seeding and before crop emergence if steam, flame or herbicides can control weed seedlings with no soil disturbance. The University of Maryland webpage The Stale Seedbed Technique discusses the technique in more detail.

The Pacific Northwest Weed Management Handbook provides current weed biology and management information for a wide range of crops and weed species.

Harvest and handling

Harvest and handling practices affect the quality and shelf life of crops. Optimum harvest times depend on crop type, maturity and sometimes your preference. Gentle handling during harvest prevents bruising or other damage that can reduce shelf life and storability. Storage conditions also influence quality whether your crops are stored short-term or long-term.

For more information on harvest timing and postharvest handling, search the University of California's Commodity Fact Sheets and Post Harvest Center Bookstore. The ATTRA publication *Postharvest Handling of Fruits and Vegetables* is also helpful. The "Crop management" section below discusses some harvest and handling considerations for specific winter vegetables.

You can also consult with Extension, seed company representatives or experienced farmers.

Food safety is also a concern in crops grown for human consumption, especially those that might be eaten raw. Practices during harvest and handling have a large impact on the safety of produce. For more information, see the Iowa State University publication *On-farm Food Safety: Cleaning and Sanitizing Guide*. Cornell University's National Good Agricultural Practices Program also provides extensive information.

Chapter 3

Crop management

This chapter provides more specific crop production and culinary information for winter vegetables on your small farm or garden. More information is also available in the OSU *Vegetable Production Guides*. The crop varieties listed in this chapter are popular with experienced local growers and are included to help you get started. For more varietal information see the OSU's Vegetable Variety Selection Resources and the Organic Seed Alliance's variety trial results and other publications.

Growing biennial vegetables

Most of the crops in this publication are biennials, meaning they take two years to grow from seed to seed. This influences crop management practices. In year one, biennial crops put on vegetative growth. Vernalization (stimulation of spring flowering in biennial crops) is induced by low temperatures over time. The duration of cold weather needed varies by crop and variety. Strong biennials with relatively long vernalization requirements need as much as 6–8 weeks below 50°F degrees. Vernalization takes longer than 6–8 weeks if daytime temperatures are above 50°F and some brassica species such as cabbage may even "reset" to prevernalization status if temperatures rise in late winter, as sometimes happens in February. This requires additional vernalization. In year two, if the crop has been vernalized, they put on more vegetative growth, bolt and start flowering. Most crops are harvested before bolting or at peak bud development (such as sprouting broccoli and cauliflower).

Vernalization requirements have important practical implications when planning for successive harvest of biennial winter vegetables. Staggered planting dates allow farmers and gardeners to plan for continual harvest of many summer vegetables, but the vernalization requirements of biennial winter vegetables override time and temperature (degree-days) as a determinant of crop maturity. Two plantings of the same cultivar at different dates may start winter at different sizes, but will switch to reproductive growth at the same time if they receive the same hours of chilling. Planting date and degree days influence crop size and growth-stage of biennial crops at the beginning of winter, then the specific vernalization requirement physiologically triggers the plant to flower after warm temperatures return. Vernalization "resets" degree-day accumulation. After vernalization, degree-days again influence the time to harvest, and this varies significantly by variety. For this reason, most varieties of a biennial winter vegetable crop are planted at the same time. Select varieties that mature at different rates in the spring (after vernalization) in order to plan for successive harvest.

Photo: Anna Ashby
Figure 11. Overwintering onions, such as these 'Walla Walla' varieties, should go into the winter small in diameter, about pencil size, so that bulbing will begin in spring for a late spring to early summer harvest.

Winter vegetables have to be at different growth stages when winter arrives in order to produce a good crop. That growth stage varies depending on the crop. For example, sprouting broccoli and cauliflower should have large vegetative frames at the beginning of the winter that will support development of good heads in the spring after vernalization. However, overwintered onions must be small and juvenile, about pencil size, so that they don't vernalize and bolt in the spring before bulb development (Figure 11).

Day length can also affect the development rates and growth stages of winter vegetables. For example, in bulb crops such as onions and garlic, increasing day length initiates bulb development. See the "Alliums" section below for more information.

Seed sources

Some seed companies distribute winter vegetable varieties that are well-adapted to our soils and climate west of the Cascades. The partial list below includes companies that are active in the Pacific Northwest. These companies are popular with the farmers featured in this publication (see the "Farmers growing winter vegetables" section) and other experienced winter vegetable growers. Seed company staff can recommend suitable varieties. Many of these companies conduct ongoing variety trials in the Pacific Northwest and some also breed vegetable varieties. Some of the companies are locally based and locally owned. This list is in alphabetical order and is for information only; inclusion or exclusion of a company from this list does not imply a recommendation of any sort:

- Adaptive Seeds
- Garlicana
- Gowan Seed Company
- High Mowing Organic Seeds
- Johnny's Selected Seeds
- Osborne Quality Seeds
- Siskiyou Seeds
- Territorial Seed Company
- Victory Seeds
- Wild Garden Seed
- Wild West Seed

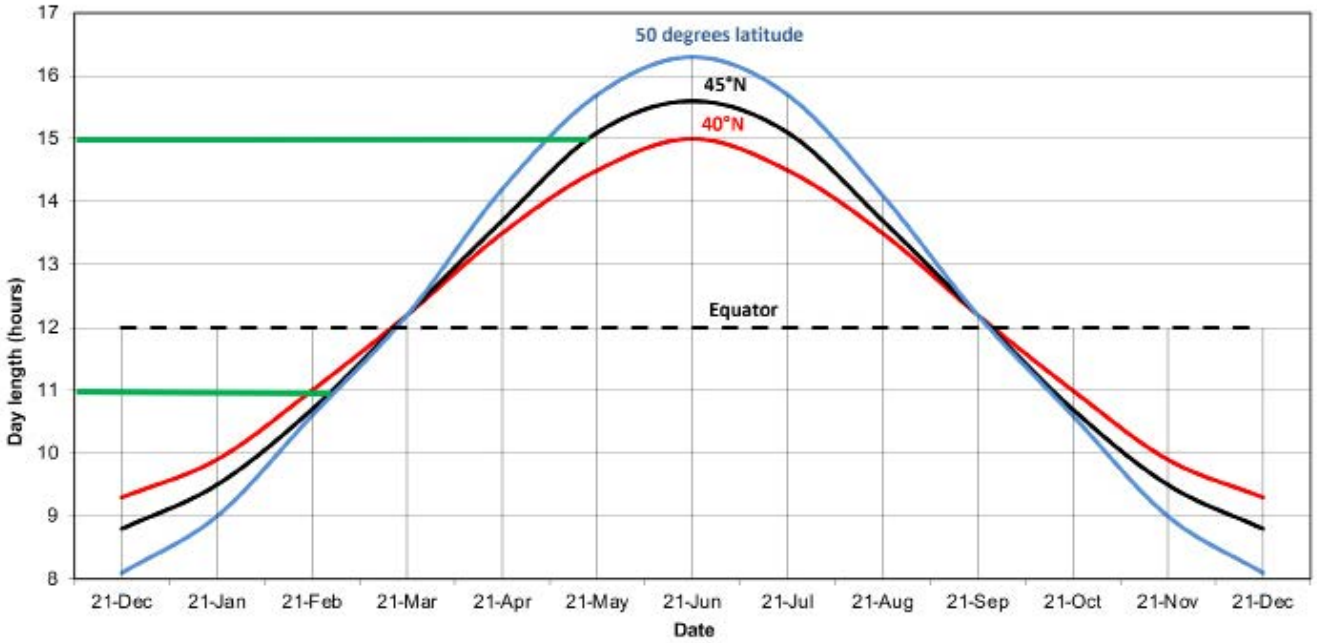
Well-stocked garden centers often carry fall and winter vegetables for transplanting in late summer, and often identify the expected harvest season based on the variety. Varieties may be limited. For more options, grow your own transplants from seed. Some popular varieties for winter production are included in each crop section below.

Alliums

Including onions, garlic, leeks and shallots

For alliums, understanding the physiology of bulb formation and bolting (forming a flower stalk) are important for cultivar selection and overall success. Day length is the major stimulus for bulb formation. As day length increases, bulb initiation is triggered. The critical day length varies by variety, and long-day onions are adapted for the Pacific Northwest. Short-day onions start bulb formation when day length reaches about 10–12 hours.

Photo: Shawn Linehan Photography
Figure 13. Hard neck garlic produces a scape (flowering stalk) in May or June, which can be harvested separately and used in culinary dishes.



Courtesy of Jim Myers, Oregon State University.
Figure 12. Day length at different latitudes in the Pacific Northwest at 40°N (red curve), 45°N (black curve) and 50°N (blue curve). Dates of bulb initiation on the x-axis are shown for an 11-hour, short-day onion variety that is not adapted to northern latitudes, and a 15-hour, long-day onion variety that is well adapted (intersection of green lines with day length curves).

Long-day onions initiate bulbing with about 14–16 hours of sunlight. Figure 12 shows the approximate dates of bulb initiation for short- and long-day onions (green lines) at different latitudes in the Pacific Northwest (red, black and blue curves). The Canadian border is at 49°N and the California border is at 42°N. For example, an 11-hour, short-day onion grown in Salem, Oregon (45°N) would initiate bulbing on Feb. 25. The plant would be too small then to develop a large bulb and would bolt before producing a marketable crop. A 15-hour, long-day onion grown at the same location would initiate bulbing on May 18 when the plant will be big enough to develop large bulbs and a good crop.

In onions, the major triggers for bolting are day length and winter vernalization (see "Growing biennial vegetables" section). Overwintering onions planted in the fall must be small (that is, a quarter-inch diameter), going into winter, as larger onions will be stimulated to bolt before bulbs can form (Figure 11). Planting onion sets that are too large often leads to bolting. Selection of locally adapted varieties (for example, using long-day onions in the Pacific Northwest) also avoids premature bolting.

Garlic is affected by both temperature and day length; cold temperatures are needed so that bulbs can form. Garlic cloves will undergo a brief dormant period after planting, followed by a period of root and vegetative growth.

Cold winter weather vernalizes the plant and initiates bulbing and then flowering in the spring and summer. Hard neck (bolting) garlic produces a flower stalk in May or June if they have been vernalized over the winter (Figure 13), whereas soft neck (nonbolting) garlic usually doesn't unless spring temperatures are low. For more information on garlic types see *Garlic Types and Market Niches*.

Leeks do not bulb or go dormant in winter. Instead, they continue to grow slowly through the cool season. Harvest time is flexible from fall through winter, but plants not harvested by spring will bolt (Figure 14).

Culinary descriptions

Allium family vegetables are the backbone of countless dishes and cuisines throughout the world. They are versatile and share a characteristic flavor and pungency that is due to various sulfur compounds. Alliums range in flavor and pungency and are used both raw and cooked. Their flavor depends greatly on the variety and growing conditions.

Bulb onions

Freshly harvested onions (often seen sold at markets with their tops attached) have a sweeter, milder flavor than onions cured for storage. Yellow onions are an

Photo: Victoria Binning, © Oregon State University
Figure 14. Leeks are a staple winter vegetable due to their ease of production and cold tolerance. They can be kept in the ground and harvested as needed throughout the fall, winter and early spring.

Photo: Shawn Linehan Photography
Figure 15. Cipollini onions are smaller onions with a flattened appearance and a sweet flavor.

all-purpose onion; they have a balance of astringency and sweetness and become sweeter the longer they cook. White onions have a sharper and more pungent flavor than yellow onions. Red onions have a strong but sweet flavor. They are often consumed raw because they lose color when cooked.

Cipollini onions and shallots

Cipollini means "little onion" in Italian. They are distinctive, small-bulb onions with a slightly flattened shape (Figure 15). With thin skins and a translucent white flesh, they are sweeter than other onion bulbs, which makes them perfect for roasting or caramelizing. Shallots are also smaller than other bulb onions and have a sweet, delicate, slightly garlic flavor.

Garlic

This bulb has the strongest flavor and pungency of the alliums. Raw garlic can be especially strong with a hot bite that mellows and sweetens considerably with cooking.

Field preparation and planting

Alliums are shallow-rooted and prefer coarse-textured (sandier) moist soils with abundant nutrients for much of their life cycle. They can be planted as seeds or transplants (green onions and leeks), sets (bulb onions), or bulbs/cloves (shallots and garlic). Green onions and leeks are normally transplanted in the field either by hand or with a mechanical transplanter.

Do not overcrowd bulb onions as this can distort the shape of the bulb; allow 6–8 inch in-row spacing. Leek transplants can be planted 3–4 inches deep in individual holes or trenches to produce long white stems. Soil can also be hilled around the stems as the plant grows larger. See Table 2 for typical planting times of different crops.

Plant nutrients

Alliums have moderate requirements for nitrogen. Bulb onions have relatively high requirements for phosphorus and potassium, and other alliums have modest phosphorus and potassium requirements. Sulfur contributes to the pungent flavor of alliums.

Application of sulfur fertilizer has increased pungency in some Treasure Valley Idaho trials, but normally enough sulfur is available from other fertilizers or organic amendments.

Once bulbing has started, nutrient requirements diminish. Cut off water two weeks prior to harvest except with leeks. For more information see *Nutrient Management for Onions in the Pacific Northwest* (PNW 546), *Nutrient Management for Sustainable Vegetable Cropping Systems in Western Oregon* (EM 9165), and *Soil Nitrate Testing for Willamette Valley Vegetable Production* (EM 9221).

Diseases

Clean, disease-free planting stock is especially important for preventing diseases in alliums. Many diseases can be prevented by purchasing clean stock from reputable sources and inspecting bulbs prior to planting.

Potential diseases that can be brought to the field on planting stock include white rot, basal rot and botrytis. Infection by white rot may make the soil unusable for alliums for many years. If you are saving your own garlic or shallots for replanting, avoid infested fields and inspect the bulbs closely for symptoms of these diseases.

Common diseases in winter alliums include the following:

- *Botrytis squamosa*: This is a foliage-infecting pathogen that is problematic during cool, wet weather. The pathogen overwinters in field debris. Crop rotation and removal of debris is helpful to reduce infection. For more information see Onion – Botrytis Leaf Blight.
- Bulb rots: Several bacteria and yeast can cause bulb rots. These pathogens favor flooded fields and wet weather. The pathogens often enter the plant through wounds. For more information see Onion – Bulb Rots.
- Neck rot: Neck rot is caused by *Botrytis aclada*. Symptoms appear initially as water-soaked tissue that will turn bulbs soft, especially in storage. The pathogen overwinters on plant debris or in the soil and can also be seedborne. Excess nitrogen, wet conditions and improper curing or storage can contribute to crop losses. For more information see Onion – Neck Rot.
- Rust: *Puccinia allii* is distinguishable by yellow flecks and spots, which become orange and elongated. Disease development is favored by cool, wet weather. To reduce pathogen incidence, rotate crops, plow under crop residue and provide good spacing to promote air movement. For more information, see Garlic – Rust.
- White rot: *Sclerotium cepivorum* infects plants in the Allium genus, causing basal leaf decay, white fungal mats and root rot, sometimes leading to plant death. This fungal pathogen's sclerotia (resting body) can survive in the soil for 20–30 years, making growing alliums in infected soils very difficult. Use pathogen-free planting material. Hot-water seed treatment can be used for garlic.

However, it will not destroy all the pathogen within the cloves. Be sure to buy bulbs from known sources that are not grown in infested fields. Inspect bulbs for visible signs of white rot. For more information see Onion – White Rot.

- Nematodes: Several species of nematodes can occur on alliums. Symptoms include stunting, root lesions, yellow tops and premature ripening. Wounding by nematode feeding can increase infection by pathogens. Rotate crops and use clean planting material. Hot-water treatment is sometimes used in garlic, but does not kill nematodes in intact bulbs. Nematodes can be transmitted on bulbs but not on true seed. See the following OSU web pages for more information on lesion nematodes, stubby-root nematodes and stem and bulb nematodes.

Refer to the *Pacific Northwest Disease Management Handbook* for details about other allium diseases.

Pests

Pests with a broad host range that can damage alliums are discussed in the "Field management" section above. Host-specific pests that are common in winter alliums include:

- Eriophyid mites: Eriophyid mites (*Aceria tulipae*) are the most important insect pest of garlic in the Pacific Northwest. These mites feed on living clove tissue and reduce quality and storage potential. See Eriophyid mites on stored garlic and Cornell University's Eriophyid mites – micro-scourge of garlic for more information.
- Bulb mites: *Rhyzogyphyus* spp are shiny, white mites which are found under the root palate of onion bulbs and garlic cloves. Damage from mites allows for entry of disease. Mites stunt plant growth and promote rotting diseases in storage. Rotate crops, inspect and use clean planting material to avoid this pest. Bulb mites can be transmitted on bulbs and onion transplants, but not on true seed. For more information see Onion – Bulb mite.
- Cutworms/armyworms: Various species of armyworm and cutworm consume foliage of alliums. Life cycles vary, therefore feeding can occur during spring, summer and fall. Fall tillage to destroy overwintering pupae and weed management are important for these insects.
- Thrips: *Thrips tabaci* are very small insects about 0.03-inch long. They cause stippling damage and can often be found feeding at the base of leaves. Thrips can reduce bulb size of onions and reduce marketability of leeks. Populations increase on weeds, therefore manage weeds and practice field sanitation. Bright green (glossy with thin wax layer) leaf varieties are less attractive to thrips than blue-green (nonglossy with thick wax layer) leaves. Minute pirate bug (*Orius insidiosus*) and other predators can help reduce thrips populations. For more information see Onion – Thrips.

Refer to the *Pacific Northwest Insect Management Handbook* for detailed information about other pests that can damage winter alliums.

Weeds

Due to the shallow-rooted and slow-growing nature of allium crops and foliage that does not shade out weeds, alliums are susceptible to reduced yield due to weed competition. Keep the crop free of weeds, especially during establishment. Try to rotate alliums to fields where weeds haven't recently gone to seed in large numbers and where weed pressure is low.

Harvest and handling

Harvest mature bulb onions when most of the necks are soft and tops have fallen. You can roll or bend the tops down by hand to hasten the drying process. Lift from the field with digging forks or a mechanical harvester, trim roots and strip off dead outer leaves. Winter-grown onions are more succulent and have fewer protective scales, so use care when handling and protect from sunscald when curing.

For garlic, check for harvest maturity in late June-early July. Garlic is ready when the head or bulb is plump with numerous cloves and the skin is dry and papery. Garlic left in the ground too long will not store well. Shallots should be harvested when they have a hard skin with rich color and are 1–2 inches in diameter. Leek and green onion (scallion) harvest is flexible due to winter field storage and can vary by planting date, variety or market conditions. See Table 2 for typical harvest times of different crops.

Cure onions, shallots and garlic before storing them. Wet weather during harvest will require indoor curing. Cure them in a dry, shaded area with good air circulation until the skins are dry, then remove tops and roots. After curing, store them in a cool, dry area until sale or use. See Drying and Curing for more information.

Yellow pungent bulb onions are best for storage followed by red and white types. Cipollini onions store well for a long time. Shallots store longer than onions. Soft-neck garlic stores longer than hard-neck types. Leeks and green onions hold in the field and can be refrigerated or stored in a cooler after harvest. Sweet onions, leeks and green onions are perishable after harvest.

Photo: Clint Taylor, © Oregon State University
Figure 16. Winter-grown cabbage heads, such as the 'Mammoth Red Rock', are less dense than those grown in summer. This cabbage head is mature and ready to harvest.

Varieties

Popular cultivars of winter alliums include:

- Garlic: 'Italian Late', 'Kilarney', 'Music', 'Nookta Rose' and 'Premium Northern White'
- Leeks: 'Bandit', 'Belton', 'Blue Solaize', 'Curling', 'Giant Musselburg', 'Gladius', 'King Richard', 'King Sieg', 'Lexton', 'Liege', 'Mechelen', 'Megaton', 'Pancho', 'Siegfried Frost', 'Tadorna' and 'Verdonnet'
- Onions: 'Bianco di Maggio', 'Desert Sunrise', 'Red Rock' and 'Walla Walla'
- Shallots: 'Ambition', 'Conservor', 'Ed's Red' and 'Sante'

Heading brassicas

Including brussels sprouts, cabbage, cauliflower and sprouting broccoli

Heading brassicas are usually hardy to zones 8 and 9. Night-time temperatures below 15–20°F can damage or kill some winter brassicas and cold tolerance varies among varieties. Sudden temperature drops without snow are more damaging than extended cold with snow. Winter cauliflower, cabbage and broccoli are all less dense than their summer counterparts (Figure 16). Savoy and semi-savoy cabbage varieties are especially cold hardy. Most consumers buy summer varieties imported from warm climates, but there is a year-round market for locally grown heading brassicas.

Culinary descriptions

Brussels sprouts

Like many winter vegetables, cold weather brings out the sweetness of Brussels sprouts. They taste similar to cabbage and they can be prepared in many different ways. To prepare sprouts for sautéing or roasting, remove yellowing leaves and cut in half or quarters rather than leaving whole. A common problem with Brussels sprouts is overcooking, so be sure to cook until just tender, not allowing them to become mushy whether you are sautéing, roasting, boiling or steaming. Sprouts can also be finely sliced or shredded raw and used in a salad or slaw. Brussels sprouts pair well with olive oil, bacon, roasted nuts, blue cheese and whole grains.

Cabbage

Crisp and pungent, cabbage is very versatile and can be used raw and shredded in salads and slaws, pickled, or cooked in many ways, including steaming, roasting, braising and sautéing. Savoy cabbage is a little more tender than smooth cabbage without the same raw

Photo: Heidi Noordijk
Figure 17. This 'Purple Cape' cauliflower is ready for harvest and shows some of the diversity available. It usually overwinters well and can be harvested through March. Some local seed companies are maintaining this variety.

Photo: Anna Ashby
Figure 18. Like Brussels sprouts, the harvestable kalette vegetable is formed on axillary buds on the main stalk. This variety is 'Kaleidoscope Mix', an F1 hybrid that comes in a mix of colors.

crispness, so it's often best when cooked. Cabbage pairs well with ginger, garlic, beets and rich meats like beef, lamb and pork.

Cauliflower

Cauliflower flavor is at its best in winter and into early spring after the cold weather has brought out its sweetness (Figure 17). The vegetable is consumed both raw and cooked, but roasting brings out the deepest flavor.

Cauliflower's flavor is delicate, so recipes can go in two different directions — one pairing it with other mild flavors and the other pairing with stronger flavors. The more delicate recipes pair cauliflower with ingredients such as leeks, parsley and butter that make for simple dishes. Cauliflower is also paired with bolder ingredients like hot peppers, horseradish, mustard, lemon, capers, olives, curry, garlic, aged cheese and vinegar.

Kalettes

Kalettes are a cross between kale and Brussels sprouts. Like Brussels sprouts, the plants form tall stalks bearing axillary buds, also known as florets (Figure 18). Kalettes can be used in similar ways to Brussels sprouts but they cook much faster. A great way to use them is left

Photo: Anna Ashby
Figure 19. Sprouting broccoli, variety 'Rudolf'. The main head and side shoots are ready for harvest.

whole, tossed in olive oil and salt, then spread out on a baking sheet. Don't overcrowd the pan; that will result in steaming the kalettes. Place in a 400°F oven and roast until they begin to brown at the edges. Toss with lemon zest, parmesan and chili flakes. The same method can be modified to have an Asian flair with fish sauce, mint, cilantro and minced peanuts. The combinations are endless for a simple roasted dish.

Sprouting broccoli

Sprouting broccoli is gaining popularity as a gourmet produce item distinct from traditional summer broccoli types (Figure 19). The best varieties have tender stems, sweet flavor and buds that are about 2 inches across and a beautiful purple color. Roasting is the preferred cooking method for bringing out the best flavor and is often simply dressed with olive oil, lemon and hot pepper flakes. Sprouting broccoli can also be blanched briefly, then plunged in an ice bath and drained to be used alongside other vegetables to be dipped in romesco or other sauce.

Field preparation and planting

Heading brassicas are usually transplanted but can also be direct-seeded. They are cold-tolerant plants that can suffer from high temperatures during transplant production in greenhouses or shortly after transplanting. Transplant into preirrigated fields and avoid drought stress during establishment. Use shade cloth, ventilation or both to reduce heat stress during hot weather in greenhouses. Allow three to four weeks for seedlings to get two to four true leaves before transplanting.

In the maritime Pacific Northwest, Brussels sprouts and kalette are planted in late spring or early summer and other heading brassicas are planted in late July or early August. Genetics (that is, cultivar or variety) then determines the specific harvest date.

Cabbages, Brussels sprouts and kalettes form heads or sprouts in the fall, and these grow larger in the spring before flowering. The heads and sprouts are vegetative structures that are harvested before flower initiation. The earliest stages of flowering (bolting or splitting) marks the end of harvest (figures 22a and b). The length of time they can "hold" in the field without bolting varies by cultivar.

Winter cauliflower and sprouting broccoli heads are the flower buds; they are harvested after the plants have been vernalized by cold winter temperatures and flowering has been initiated. Petal emergence or flower stalk elongation marks the end of harvest. The time of flower initiation in the spring varies by cultivar, so choose cultivars with different maturity dates to stagger harvests. For example, in OSU winter cauliflower trials, 'Purple Cape' and 'Medaillon' matured in February or early March, followed by 'Fredor', 'Picasso', 'All the Year Round' and 'Prestige', which matured in March or early April. Similarly, the sprouting broccoli cultivars 'Rudolph', 'Red Blaze' and 'Rioja' matured before 'Mendocino', 'Red Arrow', 'Purple Reign', 'Red Fire' and 'Bonarda'." See Table 2 for typical planting times of different crops.

Plant nutrients

Brassica crops require a lot of nitrogen. However, in fields and gardens with a history of high rates of organic amendments like cover crops, compost or manure, little or no preplant fertilizer may be needed for heading brassicas planted in late summer.

Preplant soil nitrate test results greater than 25 parts per million indicate that no additional nitrogen is needed at transplanting. pH and macro- and micronutrients are managed as indicated in *Nutrient Management for Sustainable Vegetable Cropping Systems in Western Oregon* (EM 9165). In early spring, some supplemental nitrogen can be helpful for overwintered heading brassica crops. For more information about nutrient management in heading brassicas, see the "Field management" section above and references cited there.

Diseases

Clean, disease-free planting stock is important for preventing seed and soilborne diseases in brassicas. You can prevent many diseases by purchasing clean seed and transplants and with seed treatments. See "Black leg" section below for brassica seed-testing requirements.

A five- to six-year crop rotation without brassica family crops or weeds can reduce the risk of clubroot, black leg and other diseases that are specific to brassica crops. In practice, this may be difficult because so many popular crops are in the brassica family, and weeds in the brassica family are also fairly common west of the Cascades. White mold (discussed in the "Field management" section) has a very wide host range and cannot be readily controlled by crop rotation. Other diseases that are more specific to winter brassicas include:

- Clubroot: *Plasmodiophora brassicae* is easy to identify from the club-like galls formed on plant roots. Avoid bringing clubroot onto your farm or garden, or spreading it if you find it. Avoid planting winter brassicas in fields with a known history of clubroot. If you have to plant into an infested field, increase in-row pH to at least 7.0 by applying agricultural lime. Clubroot spores have a four-year

half-life. Rotations of four to eight years with no brassica family crops can reduce disease risk. For more information, see Integrated Clubroot Control Strategies of Brassicas: Nonchemical Control Strategies.

- Black leg (*Phoma lingam*), light leaf spot (*Cylindrosporium concentricum*) and white leaf spot (*Pseudocercosporella capsellae*) are important diseases that have recently been introduced to Oregon. Winter brassica crops are at high risk from black leg and light leaf spot because they are vulnerable hosts during the main infection period in the fall and winter. Oregon and Washington require that all brassica seed planted has a negative test result for black leg in order to help manage this new disease. Few seed packets in garden centers indicate whether they have been tested. However, some seed company websites describe their testing policy. Check with your supplier to make sure the seed you use meets this requirement. For more information see Black Leg, Light Leaf Spot, and White Leaf Spot in Western Oregon.

Refer to the *Pacific Northwest Disease Management Handbook* for detailed information about the range of diseases that can damage winter brassicas.

Pests

Pests with a wide host range are discussed in the "Field management" section. Cabbage maggot is discussed in the "Root crops" section. Other common pests of heading brassicas include the following.

Cabbage aphids: *Brevicoryne brassicae* can cause serious problems on Brussels sprouts, winter cabbages, kale and other winter brassicas (Figure 20). Populations often stay low during the summer and increase to damaging levels in late summer or fall. Generalist aphid predators like hoverflies (Syrphydidae family), green lacewings (Chrysopidae family), ladybird beetles (Coccinelidae family), and predatory midges (*Aphidoletes aphidimyza*) contribute to aphid control. The specialist parasitoid (*Diaeretiella rapae*) is also common in aphid colonies and easily recognized by the light brown mummified aphid exoskeletons left behind after the adults emerge from their host. Together these natural enemies help to keep aphid populations down but often not enough to prevent crop damage. Enhancing natural enemies by providing pollen and nectar sources for adults can increase aphid predation and parasitism significantly, and potentially reduce the risk of crop losses.

Drought stress can increase leaf nitrogen levels and may increase crop susceptibility to aphids. Some varieties with glossy, bright green leaves are less preferred by cabbage aphid and more preferred by their natural enemies, while varieties with nonglossy (that is, blue-green) leaves are more preferred by aphids. This difference is due to wax type.

Photo: Neil Bell., © Oregon State University
Figure 20. Cabbage aphids infest the harvestable part of the plant and can cause the crop to be unmarketable, especially Brussels sprouts and cabbage.

Cabbage aphids reproduce very quickly and can often reach damaging levels in the fall despite preventive methods. Monitor susceptible crops and treat if aphids reach damaging levels. This University of California website on cabbage aphid provides suggested monitoring methods and treatment thresholds. This research report from the University of New Hampshire found some organically approved insecticides to be effective when treatments were started in response to monitoring. For more information on aphids in brassica vegetables and management options, see Broccoli, Brussels sprout, cabbage, cauliflower – aphid.

Brassica flea beetles: *Phyllotreta cruciferae* and *P. albionica* are black shiny flea beetles that feed on brassica plants. They are different than *Epitrix* species that feed on crops in the *Solanaceae* family (that is, potatoes, tomatoes, pepper, eggplants). Flea beetles have enlarged hind legs that allow them to jump when disturbed. This normally makes them easy to identify. Brassica flea beetles cause shothole damage to leaves, and heavy populations can stunt or kill young brassica transplants. Nonglossy (blue-green) leaved varieties are less preferred by flea beetles, but this effect appears to be weaker than the opposite effect with cabbage aphids. Floating row cover can be used to protect plants during crop establishment and more mature heading brassicas can usually tolerate some leaf damage. For more information, see *Organic Management of Flea Beetles.*

Cabbage whitefly: *Aleyrodes proletella* has recently been introduced to the Pacific Northwest. It has been observed displacing cabbage aphids in the Portland area, and may have the potential to become a serious pest in

the region. Fortunately, it is not known to vector plant viruses. For more information, see Pest Alert: Cabbage Whitefly and New Pest of Brassicas in Oregon: Cabbage Whitefly.

Photo: Heidi Noordijk, © Oregon State University
Figure 21. Overwintering 'Nautic' Brussels sprouts shown here in late December. These sprouts are ready for harvest or can be held in the field for later harvest. Depending on the weather, harvest could continue through late February.

Photo: Clint Taylor, © Oregon State University
Figure 22a. This 'January King' cabbage head shows lengthening of the internal stem (compare to Figure 16), which is the elongating flower stalk. This reduces the quality of the head and marks the end of the harvest period.

Refer to the *Pacific Northwest Insect Management Handbook* for detailed information about other pests that can damage winter brassicas.

Weeds

Weeds are relatively easy to manage in overwintered heading brassica fields. Two to three cultivations during establishment are usually enough. The crop canopy should outcompete weeds by late September or October, and most summer weeds stop germinating in the fall. Winter weeds or cover crops growing between rows can help reduce the risk of nutrient leaching and help protect your soil over the winter and during harvest.

Harvest and handling

Brussels sprouts are often "topped" by cutting off the growing point at the top of the plant when the lower sprouts are about a half-inch in diameter. This University of New Hampshire study found that the effect of topping on sprout uniformity and yield varies with variety and harvest time. Cabbages and Brussels sprouts are harvested over the winter and in early spring before they begin to bolt (Figure 21). Early bolting marks the end of harvest. Bolting can be monitored by cutting open heads and looking for early lengthening of the internal stem in each head (Figures 22a and 22b). Cabbage heads and Brussels sprouts elongate and then split when they start to bolt. At this point, the harvest period is over.

Sprouting broccoli (Figure 19) and winter cauliflower (Figure 23) are harvested when they form mature buds. Winter cauliflower heads are a bit looser than summer

Photo: Clint Taylor, © Oregon State University
Figure 22b. This 'Ruby Ball Improved' cabbage head is splitting as the plant begins to bolt. The flower stalk expanded inside the head and is emerging.

Photo: Heidi Noordijk, © Oregon State University
Figure 23. A mature 'Caprio' cauliflower in January grown at Pumpkin Ridge Gardens, North Plains.

cauliflower. Sprouting broccoli heads are smaller and looser than summer broccoli but the side shoots are also harvested.

The earliest signs of flowering are flower stalk lengthening inside the heads in cauliflower and some sprouting broccoli. Other sprouting broccoli varieties begin to show yellow flower petals before the flower stems start to lengthen. See Table 2 for typical harvets times of different crops.

Optimal post-harvest storage climate for winter brassicas is 36°F and 98% to 100% humidity. Winter cabbages can store for as long as three months in these conditions. Brussels sprouts and winter cauliflower can last up to two months in cold storage. Sprouting broccoli only lasts a few weeks.

Varieties

Popular cultivars of heading brassicas for winter production include:

- Brussels sprouts: 'Igor', 'Nautic' and 'Redarling'
- Cabbage: 'Deadon', 'January King', 'Marabel', 'Ruby Perfection' and 'Wirosa'
- Cauliflower: 'All The Year Round', 'Fredor', 'Medaillon', 'Picasso,' 'Prestige' and 'Purple Cape'
- Kalette: 'Autumn Star', 'Misteltoe' and 'Snowdrop'
- Sprouting broccoli: 'Bonarda', 'Burgundy', 'Mendocino', 'Red Fire', and 'Rudolph'

See the Organic Seed Alliance's *Purple Sprouting Broccoli* guide for more information about fresh market and seed production.

Photo: Anna Ashby
Figure 24. 'Brilliant Lights' chard comes in an attractive mix of colors from red to gold.

Leafy greens

Including brassica greens, chard and spinach, chicories, fennel, lettuce and parsley

Leafy greens are a diverse group of crops that span several plant families. They are grown for their foliage, which may be consumed fresh or cooked. In some cases, they are used as a seasoning. Parsley is an example. Many of these crops can be grown year-round and the hardiest of them provide nutritious produce throughout the winter. See Table 2 for some general guidelines regarding cold hardiness and typical planting and harvest times of different crops. Cold hardiness and time to maturity varies widely between crop types and varieties within a crop, so check with your seed supplier for information about the varieties you are interested in growing.

Photo: Anna Ashby, © Oregon State University
Figure 25. 'Dragons Tongue' mustard is a visually appealing leafy green that is both sweet and spicy.

Culinary descriptions

Arugula

This green is also called rocket, rucola and Italian cress. Wild arugula is also called selvetica and has smaller, more-toothed leaves. With a tender texture and strong, peppery flavor, arugula has an exciting heat and bite similar to watercress and horseradish. Arugula is used raw in salad, on top of pizza and as a base for pesto. It can also be used wilted in a variety of dishes, including pasta, cooked potatoes and soups. It pairs well with olive oil, vinegar, lemon, anchovy, cheese, fruits and meats.

Chard and beet greens

Although these two are the same species and can be used interchangeably in most dishes, the flavor of chard and beet greens differ in that beet greens typically have a stronger, earthy and slightly saline flavor. Chard with colored mid-ribs (Figure 24) are more bitter and stronger than the white-ribbed types. The nonsavoy, solid green Italian 'bietola' is the mildest type. They can all be eaten raw or cooked. They can also be sautéed in olive oil and garlic then added to a gratin, frittata, omelet or scrambled eggs; incorporated into a pasta dish or soup; or served as a side dish.

Endive and escarole

Annual endive and escarole (*Cichorium endivia*) are close relatives of biennial radicchio (*Cichorium intybus*), and have a similar bitter flavor. Endive and escarole lack red pigments, so they are typically less bitter than radicchio and have sturdier leaves than lettuce. They are well-suited to eating both raw and cooked. Soaking the cut leaves in ice water for at least 30 minutes to leach out the bitter compounds, as well as cooking the leaves, mellows the flavor of both endive and escarole. The inner blanched leaves of the loose heads are much sweeter. Endive and escarole pairs nicely with nuts and nut oils; stronger flavors such as anchovy, garlic and hot pepper; rich ingredients like cheese, cream, eggs and cured meats; and hints of brightness like crisp fruits.

Kale and collards

Kale and collards are both *Brassica oleracea*. The leaves vary widely in shape, sizes, hues, waxiness and texture (that is, savoy or ruffled leaves versus smooth leaves) depending on the type and cultivar. They are heartier greens that can be consumed raw or cooked. If used raw in a salad or other recipes, leftovers can last much longer in the fridge than lettuce. For salads, it's best to cut thinly and massage the dressing into the greens or toss the greens with the dressing and allow to sit for five to 10 minutes for the kale or collards to soften slightly. Kale and collards are delicious sautéed in olive oil and garlic. Creamed kale and collards are a hardier and more decadent option. While kale has not been very popular in the United States until fairly recently, collard greens have long been a specialty of the southern U.S., where the cooking influences and preferences of enslaved or indigenous communities made these leafy greens a regional specialty. Collards, often simply called "greens," became widely adopted as the primary green

vegetable grown in many southern regions and have long served an important nutritional role for people in the Southeast. Look for traditional Southern recipes for cooking collard greens.

Mustard greens

Mustards are similar to kale and collards in many culinary applications, though much more pungent. Tender young leaves are typically milder, both sweet and spicy, and often found in salad mixes. Mature mustard greens are most commonly cooked to cool them down a bit. Frank Morton of Wild Garden Seed describes the two species of mustards he grows as follows:

- *Brassica rapa*: Mild-flavored, nutritious staples of east Asian cooking and a favorite for salad mix. Cold tolerant and taste best in cool seasons. Flowers and tender bud shoots ("rapini") are wonderful in salad.
- *Brassica juncea*: More or less pungent species often grown for broad or swollen petioles and tender bolting stems (Figure 25). They are used for salad, soup, braising or stir fry. Young plants and heart leaves are autumn salad staples. Flowering buds have a terrific flavor for an edible flower garnish.

Radicchio

Radicchio is most popular in Italy, although it is gaining popularity beyond its borders, including in the U.S. Its bitterness is probably the greatest deterrent for most people, but this is largely a product of our culture and is an acquired taste. Types of radicchio are often named after towns in the Veneto region of Italy where they are grown such as Treviso, Chioggia and Castelfranco. Varieties that are purple in color (Figure 26) are typically more bitter. The green types are milder. Eaten either raw or cooked, radicchio should first be soaked in ice-cold water for at least 30 minutes to leach out the bitter compounds. Cooking radicchio also mellows out the bitterness. Roasting, braising, sautéing or grilling radicchio will create caramelization and tame harsh flavors. Blanching beforehand also helps in that regard. Salads of radicchio are best paired with full-flavored, fatty and acidic companions like nuts, cheese, vinegar, cream and fruit (that is, apple, pear and citrus).

Types of leafy greens

This section is organized by family to help with crop rotation and pest management decisions.

Apiaceae

Fennel (*Foeniculum vulgare* and *F. vulgare* var. *azoricum*)

Fennel is from the Mediterranean region. There are herb varieties and bulb varieties. Herb varieties (*F. vulgare*) are perennial. The foliage is harvested as an herb, and

Photo: Shawn Linehan Photography
Figure 26. Closely related to chicory, radicchio can be bitter in flavor, especially the red varieties. Winter annual weeds, such as this Persian speedwell, often get established in winter vegetable crops but rarely reduce yield or cause problems during harvest.

the plants will come back each year. Bullb fennel (*F. vulgare* var. *azoricum*) is commonly known as Florence Fennel or Finocchio, and is grown as an annual vegetable for the bulb-like swollen leaf bases. Botanically, bulb fennel is a biennial.

Fennel can be direct-seeded or transplanted. Perennial types grown for the foliage have an upright habit and may grow up to 6-feet tall when in flower. Bulbing types tend to grow to about 2–3 feet tall. Regular water during the summer months is required. Fennel can tolerate light frosts but is not hardy enough to survive very cold winter temperatures.

Parsley (*Petroselinum hortense*)

There are three kinds of parsley: curly-leaved, flat-leaved and Hamburg (or turnip-rooted). Flat-leaf types have a stronger flavor. Hamburg types are often sold simply under that name. Transplanting is preferred to direct seeding parsley because germination is slow and variable.

Asteraceae

Chicory is a term used to refer to all vegetables in the *Chicorium* genus, including radicchio, but also frisee, escarole, Belgian endive and dandelion greens. Horticulturally, this is a diverse family and we only discuss a few types here.

Chicory and radicchio (*Cichorium intybus*)

These herbaceous perennial plants have diverse uses. They are normally grown as annual crops for their leaves (heading and nonheading types), blanched buds or roots. They have a wide range of common names that includes Belgian endive, Catalogna chicory or puntarelle, common chicory, radicchio and witloof. Heading types have green, red or pink leaves. Some types turn red or pink only with the onset of cool weather. They perform best under cool temperatures so are normally grown in early spring or late fall. July-transplanted varieties are harvested from October to February because different varieties have a wide range of days to maturity. External wrapper leaves are killed by hard freezes, but the internal portion of the head is still marketable after trimming. Early spring-planted varieties that are harvested in July and August are also available.

Endive and escarole (*Cichorium endivia*)

Both curly-leaved endive and some types of escarole are good fall and winter crops, though they benefit from some protection as the weather gets colder. Escarole (*C. endivia* var. *latifolia*) has broad leaves and is less bitter than other types. Endive (*C. endivia* var. *crispum*) has narrow green leaves and is sometimes called chicory or frisée.

Lettuce (*Lactuca sativa*)

Lettuce is widely grown and there are many varieties that can be grown over the winter inside a low tunnel or high tunnel. There are four main types of lettuce: crisphead, cos (or romaine), leaf and butterhead. Leaf types tend to be more winter hardy. Lettuce can be sown from seed or transplanted most of the year. Plantings in August and early September provide for harvests in late September and October. Late September or October plantings will be ready for harvest January through March. This WSU Winter Lettuce website describes different types of lettuce and includes the reports from variety trials conducted in Vancouver, Washington, from 2003 to 2005.

Brassicaceae

Arugula (*Eruca vesicaria ssp sativa*) (annual); *Diplotaxis tenuifolia* (perennial)

Arugula is also known as rocket, Mediterranean salad, rucola or roquette in Europe, and gharghir in the Middle East. Continuous cutting of the young leaves stimulates further leaf production. If the crop becomes overmature, the product becomes unmarketable. Arugula may be grown with or without protection, although it will benefit from some protection as the weather becomes colder.

Photo: Neil Bell, © Oregon State University
Figure 27. A staple in the winter garden, kale is available in many varieties that can vary widely in color, leaf type, size and flavor. Kale is very cold hardy and well-adapted as a fall and winter crop.

Broccolini

Broccolini is hybrid of Gai Lohn (*B. oleracea* var. *alboglabra*) and standard broccoli (*B. oleracea* var. *italica*). The harvestable portion of the plant resembles long, slender broccoli side shoots. They are harvested when they are nearly ready to flower. The flavor has been described as similar to broccoli but sweeter and less pungent, or as resembling asparagus.

Gai Lohn (*B. oleracea var. alboglabra*)

Gai Lohn is a popular bunching green bearing a resemblance to broccoli, consisting of tender, thickened, flower stalks and young leaves, which are harvested when two or three flowers have opened.

Kale and collard greens (*B. oleracea* Acephala Group)

Kale and collards are among the most cold-hardy crops. They are not well-adapted to hot weather, and the best quality is produced when they are grown into

the fall or winter. There are two types of kale. Scotch types have gray-green and very curled and crumpled leaves. Siberian types are blue-green and less curled. Both dwarf and tall types are available, with the dwarf types often preferred for commercial production. Some cultivars produce purple leaves and are attractive in the winter garden (Figure 27).

Mustard greens (*Brassica* spp.)

Mustard greens are a large and variable group involving a number of different species and subspecies and their hybrids. There is considerable opportunity for confusion regarding the names of different mustard greens because of their genetic diversity, their ability to intercross, and the wide range of descriptive terms used to describe them around the world.

Winter Cress (*Barbarea verna*)

One of the cold-hardiest winter greens, this native of Europe and Asia has naturalized in parts of North America. It is easily grown in gardens, although care should be taken to prevent it from going to seed and becoming a weed problem. It can be harvested throughout winter and used in many ways, such as in salads, sandwiches or soups.

Other brassica greens (*B. rapa*)

Brassica greens in the species *B. rapa* are diverse and have many different common names around the world. Many either benefit from or require some winter protection, such as a high tunnel or low tunnel west of the Cascades. Check with your seed supplier for specific growing instructions.

- Bok choy, pak choi or pok choi (*B. rapa* Chinensis group) includes a wide range of varieties, but the typical bok choy has large dark green leaves arising on upright, white or green petioles with spoon-shaped bases. The thickness and length of the petioles vary from one variety to another.
- Broccoli raab or rapini (*B. rapa* Ruvo group) is related to turnip, not brococoli, and the foliage looks like turnip greens. The plant develops early spring shoots resembling asparagus that bear mustard-like leaves and small broccoli-like heads at their tips.
- Chinese cabbage or napa cabbage (*B. rapa* Chinensis group or Pekinensis group) produces tall, cylindrical cabbage heads with thick white petioles. They are often used in Chinese cuisine.
- Komatsuna (*B. rapa* var. *perviridis*) is also known as mustard spinach or spinach mustard. They are bunching greens with dark green leaves and slender green petioles.

Photo: Neil Bell, © Oregon State University
Figure 28. Mizuna is in the mustard family (*Brassica juncea*) and has a mild peppery flavor. Mizuna is especially prolific and easy to grow.

Photo: Neil Bell, © Oregon State University
Figure 29. Tatsoi is in the mustard family (*Brassica rapa*), but is mild in flavor and often used in East Asian cooking.

- Mibuna (*B. rapa* Japonica group) produces long narrow leaves on a dense, leafy plant up to 1 foot tall. Leaves have a mild flavor. It is a traditional Japanese vegetable originally from Mibu in the Kyoto prefecture and is cold-tolerant.
- Misome (*B. rapa* Narinosa group) is a hybrid between komatsuna and tatsoi. It has an upright-growing plant up to 10 inches tall that produces deep green, thick-textured leaves.
- Mizuna (*B. rapa* var. *niposinica*) are dense spherical plants up to 1 foot tall. The serrated leaves have a mild peppery flavor and are used in salads (Figure 28). Mizuna is very cold-tolerant.

- Tatsoi: (*B. rapa* Narinosa group) grow as a low, flat rosette and produce thick, spoon-shaped dark green leaves (Figure 29).
- Turnip greens: (*B. rapa* Rapifera group) have pungent leaves that are used both fresh and in cooked dishes. They are the edible greens of turnip plants (also see Root vegetables).

Caryophyllaceae

Chickweed (*Stellaria media*)

Although chickweed is usually considered a weed, common chickweed is also a fairly cold hardy and nutritious winter annual vegetable. Plants germinate in the fall when rains commence and grow throughout the winter, flowering in the spring. Common chickweed is best grown in well-amended soil, where it responds by growing more vigorously and rooting at the nodes to produce more productive plants. Other chickweeds in the genus *Cerastium*, such as mouseear chickweed (*C. vulgatum*) are hairy and are not edible.

Chenopodiaceae

Beet greens and chard (*Beta vulgaris* Orientalis group and Cicla group)

Beet greens are a form of common table beet or leaf beet grown for their succulent leaves, which can be harvested over an extended period. Chard, also referred to as Swiss chard, is a biennial grown as an annual for leaves and stalks rather than the roots. Late spring and early summer plantings can last through a mild winter, and frost protection can further extend the season. Outer leaves may be harvested first as the plants mature.

Spinach (*Spinacia oleracea*)

With proper variety selection, spinach production for the fresh market is possible almost year-round in western Oregon and Washington. Slow-growing, slow-bolting (that is, slow seed-stalk development as day length increases) spinach varieties are used for late spring and summer harvest. Fast-growing (and usually fast-bolting), vigorous varieties should be used for fall, winter and early spring harvest.

Flat, semisavoy and savoy leaf varieties are used for different markets. The flat and some of the semisavoy varieties are used for processing. All three types are used for fresh market with semisavoy and savoy types predominating. Spinach varieties may also be classified as prostrate, semi-erect and upright. It is difficult to remove soil from savoy leaves during washing and processing, so consider practices such as cover crops or mulches to reduce soil contact. Farms that produce spinach for processing sometimes apply plant growth regulators to savoy types before harvest to encourage upright leaf growth and reduce soil contamination.

Fabaceae

Pea shoots (*Pisum sativum*) can be planted in early spring or late summer. Austrian winter peas are cold tolerant and can often be grown without frost protection. However, snow pea and snap pea varieties are preferred for their flavor and tenderness. Leafy cultivars with short stems and few tendrils are also preferred. Flowering sweet pea cultivars (*Lathyrus odoratus*) and other *Lathyrus* species are not safe to eat because they contain an amino acid that some people react negatively to. *Pea Shoots* from WSU Extension provides production, culinary, nutritional and marketing information.

Valerianaceae

Corn salad (*Valerianella locusta*)

Corn salad is also known as lamb's lettuce, maches, fetticus, feld salad or rapunzel. It is one of the hardiest winter greens and easy to grow in any garden soil. Plants are easy to establish from a seeding in mid- to late summer and eventually form small rosettes.

Field preparation and planting

Most leafy greens can be grown on a wide range of soil types, though in general, loose fertile loams with good organic matter content are preferred. Soils with good water-holding capacity help to provide uniform soil moisture before winter rains begin. Since harvest will be during wet weather in fall and winter, choose soils that drain well. Soil compaction can adversely affect growth and yield. Cover crops or natural weed cover can help to reduce mud and compaction during harvest.

In most cases, transplanting is the preferred method of establishing the crop, although direct seeding is an option for many leafy greens. Transplanting is preferred for parsley because their seeds germinate slowly, and direct seeding can significantly delay harvest.

Plant nutrients

This diverse group includes many minor crops with little specific nutrient management information for them. For more information about nutrient management, see the "Field management" and "Heading brassicas" sections above and other references cited there. pH between 6.0-6.8 is adequate for most crops.

Plant diseases

White mold can infect overwintered leafy greens and is discussed in the "Field management" section above. Some other important diseases of overwintered brassica leafy greens (that is, clubroot, black leg, light leaf spot and white leaf spot) are discussed in the "Heading brassicas" section above for information about brassica seed testing requirements in Oregon and Washington. Some other common diseases of overwintering leafy greens include the following:

- Damping off: *Pythium* spp. and *Rhizoctonia solani* are soilborne pathogens that can attack young germinating seedlings when soil is wet. Stems are attacked as young plants emerge. Plants wilt, fall over and die. Germinating seed also can be attacked, and seeds and seedlings rot before they fully germinate and emerge. Manage the crop to promote rapid and vigorous seedling growth. Do not overwater as wet potting soil or field soils promote damping off. For more information see Kale – Damping-off (Wirestem).
- Downy mildew is caused by the oomycetes (that is, water molds) in the genus *Peronospora*. In areas with mild, wet winters like western Oregon and Washington, multiple cycles of downy mildew infections can occur through the winter. Young seedlings are more susceptible than older plants and can die from downy mildew. Increased plant spacing allows foliage to dry more quickly after rain. Leaves with high nitrogen content are more susceptible, so avoid excess nitrogen fertilizer. For more information see Kale – Downy Mildew.
- Powdery mildew: the fungus, *Erysiphe cruciferarum* (syn. *E. polygoni*), can infect most crucifer crops and cruciferous weeds. Small, discrete white patches develop on both leaf surfaces. Later, patches coalesce until a powdery mass of white mycelium and spores cover the entire leaf. Stressed plants will be more susceptible to disease. Plant resistant varieties if available and avoid overapplication of nitrogen fertilizers. Practice a three-year rotation with nonsusceptible crops and manage crucifer weeds. For more information see Kale – Powdery Mildew.

Refer to the *Pacific Northwest Disease Management Handbook* for detailed information about the range of diseases that can damage leafy greens.

Pests

Important pests of leafy greens are discussed in the "Field management," "Heading brassicas" and "Root crops" sections. They include aphids, armyworm, cutworm, brassica flea beetles, winter cutworm, symphylans, slugs, rodents and deer.

Spinach leaf miner (*Liriomyza huidobrensis*) is a common pest of spinach, chard and beet greens. Adult flies lay eggs on leaves that hatch into legless larvae with no distinct head. Larvae feed inside the leaf and cause winding trails or blotches that make leaves unmarketable. For more information see Spinach-Leafminer.

Refer to the *Pacific Northwest Insect Management Handbook* for detailed information about other pests that can damage leafy greens.

Weeds

Common weed problems include annual bluegrass (*Poa annua*), common chickweed (*Stellaria media*), henbit and purple deadnettle (*Lamium amplexicaule* and *L. purpureum*), and Persian speedwell (*Veronica persica*) (Figure 26). These are all annual or winter annual weeds and will grow slowly throughout the winter months, flowering and setting seed as the weather warms in the spring.

Harvest and handling

Leafy greens are extremely perishable and need to be handled delicately and marketed quickly. If the plants are wet with rain or dew, the leaves are more turgid and break more easily. When harvesting by hand, cut above the crown or soil line and bunch. Care should be taken to exclude leaves that are dirty with soil or are yellow. Harvested plants should be cooled as rapidly as possible to preserve quality. Specialty leaf lettuces and spinach for bag mixes are typically hand-harvested, but mechanical harvesters are also available.

Most leafy greens are very perishable and are not adapted to long-term storage. Harvested produce should be stored with refrigeration as close to 32°F as possible and at 95% to 100% relative humidity. Air circulation should be adequate to remove the heat of respiration but not rapid enough to cause transpiration and wilting.

Varieties

Popular cultivars of winter leafy greens include the following:

- Arugula: 'Arugula', 'Astro', 'Ice-bred', 'Pronto', 'Roquette', 'Sputnik' and 'Tuscan'
- Broccoli raab or rapini: 'Novantina'
- Chard: 'Bright Lights', 'Fordhook Giant', 'Rainbow', 'Rhubarb', 'Ruby Red' and 'Virgo'
- Collards: 'Bulldog', 'Champion', 'Flash', 'Hi-crop' and 'Vates'
- Endive and escarole: 'Full Heart Batavian', 'Lorca', 'Ruffec' and 'Salanca'
- Fennel: 'Orion', 'Perfection' 'Preludio', 'Romy' and 'Victorio'
- Kale: 'Black Tuscan', 'Darkibor', 'Dazzling Blue', 'North Star Polaris', 'Red Chidori', 'Red Ursa', 'Redbor', 'White Russian', 'Wild Garden Lacinato' and 'Winterbor'
- Lettuce: 'Cardinale', 'Continuity' or 'Merveille de Quatre Saisons', 'Flashy Trout's Back', 'Hungarian Winter Pink', 'Jadeite', 'New Red Fire', 'Oak Leaf', 'Red-Tinged Winter', 'Romaine Dark Green', 'Top Gun', 'Victoria' and 'Winter Density'

- Mustard greens: 'Dragon Tongue', 'Golden Frills', 'Green Wave', 'Ruby Streaks' and 'Golden Frills'
- Parsley: 'Deep Green', 'Forest Green' and 'Moss Curled' are curly leaved types; 'Deep Green Italian', 'Plain' and 'Plain Italian Dark Green' are flat-leaved
- Radicchio, Treviso and Chicory: 'Augusto', 'Bottiglione', 'Castelfranco', 'Chioggia', 'Franchi', 'Grumolo', 'Palla Rossa', 'Rosalba', 'Rossa di Treviso', 'Rubello', 'Rubro' and 'Treviso'
- Spinach: 'Abundant Bloomsdale', 'Gazelle', 'Giant Winter', 'Hammerhead', 'Long Standing Bloomsdale', and 'Winter Bloomsdale'

Legumes

"Fava beans," "faba beans" or "broad beans" (*Vicia faba*) are an erect and determinate relative of vetch that is native to the Mediterranean region.

They can overwinter well in some areas of western Oregon and Washington, or can be planted in early spring as soon as the soil is workable. They can tolerate temperatures down to 15–20°F, and are more cold-tolerant when they are small going into winter (Figure 30). Culinary varieties are large-seeded, while small-seeded varieties are bred as cover crops. In the spring, some farmers and gardeners harvest the growing tips of fava beans. See the "Leafy greens" section on Fabaceae for more information about tendrils.

Culinary descriptions

Fresh green fava beans are a labor of love, but well worth the time and effort to prepare them. The first step in preparation is to remove the beans from their large pods (Figure 31), then blanch the beans in boiling salt water for just a minute or two before immediately draining and rinsing in cold water to stop further cooking. Cut a slit in the pale green bean membrane of each bean with a paring knife and squeeze out the inner bright green fava. Fresh fava beans can then be added to many dishes. They are often used in a warm or cold pasta dish or grain salad. Favas are delicious mashed by hand or with a food processor into a spread with basil or mint and olive oil. A traditional Italian way to enjoy the spread is simply on bread with Pecorino cheese. If you have young, small-podded fava beans, you can eat these cooked whole as the pods are not yet fibrous. The whole pods are often tossed in olive oil and salt then grilled or roasted on high heat. Fava greens taste like the beans and are an early spring treat eaten raw or sautéed and paired with Asian flavors like soy, sesame, tofu, ginger and garlic.

Field preparation and planting

Fava beans do best on well-drained silt loam or sandy soils. Culinary fava beans have very large seeds (≥1.0 g/seed). They are normally direct-seeded, but can also be transplanted. Mechanical seeding is difficult because the seed is so large. Cover crop fava beans have smaller seeds for easier seeding, but the beans are not used in cooking. Not all culinary varieties are winter hardy west of the Cascades. Late-planted fava beans (that is, late September or early October) are smaller and more cold-hardy going into the winter (Figure 30). Plants that are large going into the winter are less cold-hardy than small plants (that is, more than about six true leaves). Plants are normally spaced 5–6 inches apart in the row with rows 24–36 inches apart. See Table 2 for typical planting times for fava beans.

Photo: Victoria Binning, © Oregon State University
Figure 30. These fava beans at Ayers Creek Farm are young enough to overwinter quite well in western Oregon.

Photo: Shawn Linehan Photography
Figure 31. Fava beans (or broad beans) are grown over the winter and harvested in May–June for green favas, or in July–August for dry beans.

Plant nutrients

Legumes do best in neutral or slightly acidic soils. Apply lime if pH is below 5.8. All legumes can develop symbiotic relationships with *Rhizobia* spp bacteria in the soil. Rhizobia convert elemental N_2 in the atmosphere to plant-available ammonium nitrogen (NH_4–N). To encourage this symbiotic relationship, inoculate your seed with *Rhizobium leguminosarum* bv. vicia. Commercial inoculant type F (fava bean and lentil) or

E (field pea and vetch) work well. If the right strain of Rhizobia is rare in the soil, or if the soil already has plenty of mineral N for crop growth, legumes don't readily develop this symbiotic relationship. Little to no nitrogen fertilizer is needed if the seed is inoculated. Refer to the "Crop management" section for more information about nutrient management for fava beans.

Diseases

Plant diseases are usually not severe on fava beans. Sometimes mosaic viruses have been observed that are suspected to include a complex of pea enation mosaic, red clover vein mosaic and pea streak viruses. White mold can also infect fava beans (see "Field management" section).

In some areas west of the Cascades, chocolate spot (*Botrytis fabae)* can be severe. It is a fungus that causes small red-brown spots on leaves, stems and flowers. As the lesions enlarge, the center of the spot dies and turns grey. Flowers can be aborted, and in severe infections on the stem, the plants can fall over. The fungus survives as sclerotia in the soil and can also be seedborne. Crop rotation and the use of clean seed can help manage chocolate spot. Avoid saving seed from infested crops.

Pests

Important generalist pests of fava beans are discussed in "Field management." Beans are relatively tolerant of high symphyla populations. Host-specific pests include:

- Black bean aphid: *Aphis fabae* can attack overwintered fava beans in the fall. In the Pacific Northwest, they die over the winter and populations don't reach damaging levels in the spring. For more information see Bean, snap – Aphid.
- Pea leaf weevil: *Sitona lineata* feeds on leaves causing semicircular notches on the leaf margin. They normally don't do any economic damage. For more information see Bean, snap – Pea leaf weevil.

Weeds

Fava beans have large seeds and are relatively quick to establish. They also have an upright stature, so they are not difficult to cultivate. When growing conditions are favorable, they are competitive with most weeds. Cultivation is often not possible for late plantings as soil is too wet. Manage weeds before planting, and use a stale seedbed if possible.

Harvest and handling

Harvest green fava beans when the pod is thick with mature beans but still green and succulent. The pod should still be green and have a glossy sheen. Store the beans in the pod at 32°–40°F with 90% to 95% relative humidity. They are best consumed within five to seven days. Fava beans can also be allowed to mature into a dry bean later in the summer. See Table 2 for typical harvest times for fava beans.

Varieties

Popular varieties of fava beans include 'Broad Windsor' and 'Sweet Lorane'.

Root crops

Including carrots, parsnips, celeriac, turnips, rutabaga, radishes, horseradish and Jerusalem artichoke

Site selection is very important for overwintered root vegetables, especially if they are field stored. Avoid fields that are wet over the winter, or where water ponds or floods. Saturated soil makes harvest difficult or impossible and increases the risk of soilborne diseases. Root crops grow well in deep sandy, loam, silt loam or muck soils. Finely textured clay, rocky or shallow soils are not well-suited for good root production. Avoid fields that may have hard pans as this could distort root growth.

Root vegetables prefer full sun but are tolerant of partial shade. Most root crops are biennial plants from a botanical perspective. In their first year of development, they produce a storage root that can overwinter. The

Photo: Nick Andrews, © Oregon State University
Figure 32. Beets are a common winter root vegetable. Both tops and the root are nutritious and visually appealing due to pigments known as belatains.

Photo: Victoria Binning, © Oregon State University
Figure 33. Anthony Boutard, a Willamette Valley winter vegetable farmer at Ayers Creek Farm, has selected beets for vegetables with unique characteristics, such as these long beets that are desirable to chefs. When they are filleted, the slices are a similar size.

plant regrows from the storage root the following spring, flowers and sets seed in year two. Horticulturally they are treated as an annual crop because you harvest the storage root that is formed in year one. Horseradish and Jerusalem artichokes are perennial root vegetables.

Culinary descriptions

Beet

Beets (Figures 32 and 33) can be grated raw into salads and slaws for an added sweet, mineral, earthy touch, or can be pickled, boiled, steamed and roasted. Roasting brings out the best flavor, and roasted beets can be a side of their own or added to many dishes. A classic roasted beet salad includes goat cheese, citrus, tarragon or fennel. Beets can be roasted in a 350°F–400°F degree oven, wrapped in aluminum foil and placed on a baking sheet for about an hour or hour and a half, until a paring knife can easily cut through the center of the beets. Once beets are roasted until tender and allowed to cool enough to handle, the skins can easily be removed by simply rubbing them off. Roasted beets can be used in many dishes.

One delicious option is to cut roasted and peeled beets in half, mix them with breadcrumbs, parmesan cheese and eggs, then pan fry them. Serve them topped with a vinaigrette and goat or blue cheese. Dress beets with any oil and acid (vinegar or lemon juice) when they are still warm so it absorbs well.

Photo: Anna Ashby
Figure 34. Celeriac is a type of celery with edible leaves, stems and roots. It has a celery-like flavor and can be eaten raw or cooked.

Carrot

Carrots can be consumed raw, juiced, pickled or cooked in a variety of ways. They are easily and quickly grated raw into salads and slaws. Carrot salads are fantastic with toasted nuts, dried fruits and a crumbly strong or mild cheese and good olive oil. Roasted carrots are a great way to bring out more sweetness and can be nicely accented with toasted nuts, roasted beets, fresh herbs and cheese. Vinegar and olive oil can be tossed over freshly roasted carrots to brighten their flavor. Carrots are well known for being high in vitamin A due to beta carotene from their orange pigment, which is more bioavailable when cooked.

Celeriac

Celeriac is also called turnip-rooted celery, celery root or knob celery. The thick edible portion (Figure 34) is actually a swollen stem rather than a root. It is edible raw or cooked and has a mild, celery-like flavor with a starchy, potato-like texture. The leaves and stems, which are often still attached when sold at farmers markets, are also edible raw or cooked. Celeriac pairs well with creamy, rich and spicy ingredients. Topping with oil and vinegar or lemon juice when they are still warm brings out their flavor.

Parsnip

Sweet and complex in flavor, parsnips are often underappreciated. These roots can be grated raw into salads and slaws for an earthy touch, as well as boiled, steamed, sautéed, roasted and braised. Cooking brings out the sweetness in parsnips, and they are delicious pureed into soups.

Parsnips can be boiled or roasted and mashed into potatoes to add depth to traditional mashed potatoes and gravy. Or simply chop and roast along with other root vegetables in a 350°F–400°F degree oven after tossing in olive oil, salt and your favorite dried or fresh herb, like thyme.

Rutabaga

A member of the brassica family, rutabagas are a cross between a turnip and wild cabbage. They are hardy, starchy and low in moisture, thus best used boiled, roasted, mashed or braised. Simply chop and roast along with other root vegetables in a 350°F–400°F degree oven after tossing in olive oil, salt and your favorite dried or fresh herb. Also wonderful boiled and mashed with cream and butter.

Turnip

Many turnip roots are best cooked. They have a complex peppery flavor and can be tough if eaten raw. Roots can be roasted, sautéed or boiled and pureed into a soup.

Photo: Heidi Noordijk, © Oregon State University
Figure 35. Turnips are a versatile crop that add flavor and texture to many dishes. Small, thick-skinned types like this 'White Egg' variety can be eaten raw, especially when harvested small.

A favorite recipe from Heidi Swanson's cookbook *Super Natural Every Day* and one kids enjoy is to slice turnips thinly with a mandoline, toss in olive oil and salt, place on a baking sheet and bake at 425°F until golden, then remove from the oven and sprinkle with paprika and lime juice. Some turnip varieties, such as the mild spring Japanese turnips (Figure 35), are bred to produce very smooth skin and tender roots that can be eaten raw in salads.

Types of root crops

This section is organized by families to help with crop rotation and pest management decisions.

Amaranthaceae

Beets (*Beta vulgaris*) come in many different colors, from deep red to striped to bright yellow, and can be planted until early August to produce a dependable storage crop. Beets growing in climates that experience temperatures below 15°F should be mulched or harvested and held in cold storage. If you are growing for beet greens, you can continue to plant until early September.

Apiaceae

Carrot (*Daucus carota*)

Carrots grown in summer or over the winter prefer a light friable soil. A light frost will increase sweetness. A fall crop will keep in the field or garden until used or temperatures dip below 5°F. However, carrots can be damaged by soil-dwelling pests and diseases, and they often survive better in storage, without tops, than in the ground. They are available in a wide range of colors and color blends.

Celeriac (*Apium graveolens*)

Celeriac is a slow grower that is often transplanted. Plant celeriac with plenty of room to fill out, using 6- to 8-inch spacing. It can be stored in the ground, but mulch if temperatures dip below 18°F.

Parsnip (*Pastinaca sativa*)

Parsnips are very slow to emerge after seeding so consider using a stale seedbed (see "Field management" section under "Weeds"). They have a long, cream-colored tap roots with white flesh and larger foliage than carrots. Planting parsnips close together will yield smaller, sweeter roots that are easier to work with. Other traits are similar to those described for carrots.

Asteraceae

Salsify (*Tragopogon porrifolius*)/Scorzonera (*Scorzonera hispanica*)

Salsify and scorzonera, or black salsify, are closely related members of the daisy family and are very similar in cultivation and flavor. Salsify is a biennial and scorzonera is perennial. Seedlings are slow to emerge and can easily be mistaken for grass weeds. Thin seedlings to 2–3 inches apart for good root development. Scorzonera often has straighter, longer roots (up to 18 inches). They require little maintenance. Weed and water during droughty periods and harvest before roots become tough.

Brassicaceae

Kohlrabi (*Brassica oleracea*)

Both white and purple varieties are suitable for fall and winter production when planted in July or August. They are direct-seeded and thinned to 3–4 inches in the row. Harvest when stems are still small, 2–2.5 inches in diameter before the stems become woody. Later plantings may stay tender until they are 4–5 inches in diameter.

Radish (*Raphanus sativus*)

Early varieties can be direct-seeded throughout the growing season until mid-September and harvested until the onset of hard winter freezes. Use seed company spacing recommendations as they can vary from 1–2 inches for small varieites to 4–6 inches for larger daikon types. Winter radishes (oriental types and Black Spanish) should be planted in July and can be harvested all winter. Mid-summer sowings should be protected against cabbage maggots. Black radishes and watermelon radishes harvested in the winter will be milder and less spicy than those harvested in summer.

Rutabaga (*Brassica napus*) and turnip (*Brassica rapa rapa*)

Rutabaga has white flesh with red and yellowish skin (Figure 36). It is usually direct-seeded 3–4 inches apart in the row. The flesh is denser than turnips and takes longer to mature. Turnips can have white, golden or red skin and flesh, and are seeded 2–6 inches apart depending on the variety. Like other root brassicas, they are very susceptible to cabbage maggots.

Field preparation and planting

Subsoil or use a broadfork before planting root crops if hard pans are a concern in your field. Rotate crops

Photo: Victoria Binning, © Oregon State University
Figure 36. Even though the tops of many root vegetables, including rutabagas, may be damaged from cold winter temperatures, the harvestable root remains in good condition.

to avoid heavy weed pressure, soilborne diseases and root maggots before seeding root crops. Biennial root vegetables are direct-seeded into fine seedbeds. Horseradish is propagated from root cuttings and Jerusalem artichokes are propagated from tubers. Many root crops are slow to emerge, and not very competitive with weeds. Consider using a stale-seed bed strategy for weed management by preparing the seedbed a week or more before seeding (see the "Field management" section under "Weeds").

Winter root crops are usually direct-seeded between June and early August depending on the crop, variety, desired size and other considerations. Spacing is dependent on the vegetable variety; use seed company recommendations. Uniformity within and between rows is important for uniformly shaped roots and optimal yield.

Summer-seeded winter root crops require irrigation during establishment and root development. Frequent, light irrigating during the pre-emergence period helps to prevent surface crusting and hot surface temperatures, and promotes a moist and cool soil surface through which the seedlings can emerge. See Table 2 for typical planting times of different crops.

Plant nutrients

See the "Field management" section and the references cited there for nutrient management information. Table 1 shows minimum pH guidelines for some root crops grown on mineral soils. Root crops have low to medium nitrogen requirements. If preplant nitrate-N test results are higher than 25 ppm, no additional N is needed. *Soil Nitrate Testing for Willamette Valley Vegetable Production* (EM 9221) describes how to monitor soil nitrate levels and correct nitrogen deficiencies. Excess nitrogen can result in splitting, hollow stems and forked or "hairy" carrots or parsnips. Boron deficiency can cause canker in table beets. In OSU research (Hemphill et al., 1982), canker symptoms were reduced by applying boron fertilizer. For more information on nutrient management, see the "Field management" section and references cited there.

Photo: Heather Stoven , © Oregon State University
Figure 37. Many root vegetables can be stored in the field over the winter and harvested as needed. However, some pests may damage vegetables, as seen by this vole damage.

Diseases

A range of foliar and soilborne diseases can reduce yield and quality of root vegetables. See the "Field management" section for root-knot nematode and white mold information. The "Heading brassicas" section has clubroot and black leg information, which are also important in brassica root crops. Remember that the states of Oregon and Washington require that all brassica seed that is planted has a negative test result for black leg in order to help manage this new disease.

Itersonilia canker (*Itersonilia perplexans*) is a fungus that infects crops in the Apiaceae and Brasicaceae families, and is especially common in parsnip. It causes reddish-brown to black cankers near the top of the roots, and can make the plant more susceptible to secondary pathogens that can rot the entire root system. Crop rotation, well-drained fields, hilling soil at the base of the plant and the use of disease-resistant varieties can reduce this disease. See Parsnip – Itersonilia Canker for more information.

Refer to the *Pacific Northwest Disease Management Handbook* for detailed information about other diseases that can damage root crops.

Pests

Root-feeding pests can be a challenge in root crops. See discussions of slugs, symphyla, rodents and other pests with a broad host range in the "Field management" section. Other important pests include:

Cabbage maggot (*Delia radicum*) and carrot rust fly (*Psila rosae*): overwintered brassica and *Apiaceae* family root crops are seeded in mid- to late summer, which is during the peak egg-laying times for these flies. Their larvae can severely damage crops. If pest pressure is high, protect crops from female egg-laying with row covers or insecticides. Late planting and early harvest and storage can reduce pest damage and local populations.

Cabbage maggot adults are relatively strong fliers with many crop and weed hosts west of the Cascades. Local populations are usually high except in isolated locations. Carrot rust flies are weaker fliers with fewer crop and weed hosts. Farmers and gardeners can sometimes reduce their local populations and reduce damage.

Carrot rust flies can be monitored with yellow sticky traps. If weekly trap counts are zero or very low, the installation of row covers or insecticide treatments can be delayed. Observations on organic farms in Oregon suggest that early planted carrots can be used as a trap

crop if the entire early crop is harvested and the field is tilled before second-generation adults emerge, and the main or overwintering crop is planted after the end of the first generation adult flight (often late June or early July). Diligent monitoring is important to adapt this approach to any location.

For more information on cabbage maggot, see Vegetable crop pests – Cabbage maggot and this University of Massachusetts website: Cabbage Root Maggot. For more information on carrot rust fly, see Carrot – Carrot rust fly and Carrot Rust Fly Biology and Management.

Refer to the *Pacific Northwest Insect Management Handbook* about other pests that can damage root crops.

Harvest and handling

Most harvesting at the home garden and small farm scale is done by hand. If possible, the soil should be relatively dry so that a minimum of dirt adheres to the roots. Root vegetables can be pulled, dug with a shovel or lifted with a fork.

Tops are often removed prior to harvest of Jerusalem artichokes, salsify and horseradish. Handle root crops carefully during and after harvest to avoid damage and promote successful storage. See Table 2 for typical harvest times of different root crops.

If soil pests and diseases, rodents, very cold weather or mud are not a major concern, root vegetables can be stored in the ground until ready to use or sell (Figures 36 and 37). Field-stored root crops have a higher quality skin than crops stored in coolers, but the risk of damage from root maggots, rodents and other pests is higher.

Many crops taste sweeter after being subjected to low temperatures. If the roots are buried by soil, they are somewhat protected from freeze damage. Mulches may increase this protection. See Table 2 for estimates of cold hardiness, which also applies to field storage.

If root crops are harvested from wet or clayey soil, they might need to be washed to remove excess soil before cold storage. Allow washed roots to air dry because excess moisture in storage makes stored roots more susceptible to diseases. Store root crops at 32°F and high relative humidity (that is, 95% to 98%). Lower humidity can cause root vegetables to shrivel, which can be minimized if perforated film crate liners are used. In general, root vegetables are not injured by slight freezing. Remove green tops for high-quality root crop storage. Exposure to ethylene, a gas given off by apples, pears, tomatoes and other fruits, will cause many root crops to become bitter.

Varieties

Popular cultivars of winter root crops include the following:

- Beet: '3 Root Grex', 'Bulls Blood', 'Chioggia', 'Pink Stem Lutz', 'Red Ace', 'Shiraz' and 'Touchstone Gold'
- Carrot: 'Bolero', 'Napoli', 'Merida', 'Red Core Chantenay' and 'YaYa'
- Celeriac: 'Brilliant', 'Mars', 'Monarch', 'President' and 'Tellus'
- Kohlrabi: 'Azur Star', 'Delicacy Purple', 'Kossak', 'Laurentian', 'Superschmelz' and 'York'
- Parsnip: 'Albion', 'Cobham Improved', 'Javelin', 'Lancer' and 'White Gem'
- Radish: 'Cherry Belle', 'French Breakfast', 'Misato Rose', 'Pink Beauty' and 'Starburst'
- Rutabaga: 'Joan' and 'Purple Top'
- Salsify: 'Fiore Blu' and 'Mammoth Sandwich Island'
- Turnip: 'Gilfeather Turnip', 'Hakurei', 'Just Right', 'Purple Prince', Tokyo Cross' and 'Purple Top White Globe'

Planting and harvest dates and cold hardiness

Planting and harvest dates for field-grown winter vegetables vary depending on your location, crop type and cultivar. The table below provides general guidelines based on experience west of the Cascades. This information is for guidance only. It was adapted from our trials, commercial practice and information from Bejo Seeds, Inc. Adjust planting and harvest dates to your local conditions. Protection and storage can extend these dates.

Table 2. Planting and harvest dates and cold hardiness guidelines for winter vegetables west of the Cascades

Crop	Planting Method[1]	Hardiness[2]	Planting Date[3]	Harvest[3]
ALLIUMS				
Garlic	Bulb	0–15°F	Sept.–early Nov.	March–July
Leek	S	5°F	End Feb.–Mar.	Nov.–April
Leek	TP	5°F	May– early Aug.	Nov.–April
Overwintering onion	S	5–10°F	Aug.–Sept.	April–June
Overwintering onion	TP	5–10°F	Oct.–Nov.	April–June
Scallion	S	5–10°F	Aug.	May–June
Shallot	Bulb	5–10°F	Sept.–early Nov.	June–July
HEADING BRASSICAS				
Brussels sprout & kalette	TP	25–30°F	Late May–June	Oct.–March
Sprouting broccoli	TP	15–20°F	Mid July–early Aug.	Feb.–April
Winter cabbage	TP	20–25°F	Mid July–early Aug.	Nov.–March
Winter cauliflower	TP	10–15°F	Mid July–early Aug.	Feb.–April
LEAFY GREENS				
Apiaceae				
Fennel	S, TP	30°F	July	Nov.–Dec.
Parsley	TP	15°F	June–Aug.	Sept.–Apr.
Asteraceae				
Lettuce, leaf	TP	15°F	July–Aug. & Dec.–Jan.	Sept.–Oct. & March–April
Radicchio	TP	5–20°F	July	Nov.–Jan.
Brassicaceae				
Arugula	TP	20°F	June–Sept.	Sept.–April
Collards	S, TP	0°F	S: Jul TP: June–Sept.	Sept–April
Kale	TP	0°F	June–Aug.	Sept.–April
Mustard green	TP	20°F	July–Aug.	Sept.–April
Winter cress	S	15°F	Sept.	Nov.–Feb.
Caryophyllaceae				
Chickweed	S	0°F	Sept.	Nov.–Feb.

Crop	Planting Method[1]	Hardiness[2]	Planting Date[3]	Harvest[3]
Chenopodiaceae				
Beet greens	S, TP	15°F	S: July TP: Aug.	Nov.–Feb.
Chard	S, TP	5°F	S: June–July TP: June–Aug.	Nov.–Feb.
Spinach	S, TP	0°F	S: Aug.–Sept. TP: July–Aug.	Nov.–Feb.
Valerianaceae				
Corn salad	S	0°F	Sept.	Nov.–Feb.
LEGUMES				
Fava bean	S	15–20°F	Sept.–early Oct.	Green in late May–June, dry in July-Aug.
ROOT VEGETABLES				
Amaranthaceae				
Beet	S	15–20°F	June–Aug.	Oct.–March
Apiaceae				
Carrot	S	5°F	May–July	Oct.–March
Celeriac	TP	20°F	May–June	Sept.–Feb.
Parsnip	S	5°F	May–July	Oct.–March
Asteraceae				
Salsify	S	5°F	April–May	Oct.–March
Brassicaceae				
Kohlrabi	S	5°F	July–Aug.	Nov.–Feb.
Radish	S	15–20°F	Aug.–Sept.	Nov.–Feb.
Rutabaga	S	20°F	July	March
Turnip	S	10–20°F	Aug.	March

[1] TP means transplant, S means direct seed. Many crops can be transplanted or direct-seeded. We indicate the most common planting methods in the Pacific Northwest.
[2] Hardiness information was collected from seed companies, experienced farmers and our observations. They are for guidance only.
[3] In some crops such as heading brassicas, planting dates are normally consistent between varieties while harvest dates vary widely by variety.

Chapter 4

Farmers growing winter vegetables

Photo: Carrie Fay Amarp
Figure 38. Polly Gottesman, James Just and their dog Jasper of Pumpkin Ridge Gardens in their field of purple sprouting broccoli.

Pumpkin Ridge Gardens

Polly Gottesman and James Just first grew winter vegetables while participating in an internship at the Aprovecho Institute near Cottage Grove, Oregon, in 1988. When they started Pumpkin Ridge Gardens in North Plains in 1990, they started a year-round Community Supported Agriculture (CSA) program right away. Theirs was one of the first CSAs in the Portland area. Polly explained that winter vegetables have always been part of their farm vision. "I eat in the winter and we've always wanted to grow year-round and get our customers turned on to eating fresh, locally grown food all year."

Winter vegetables are integral to their farm plan. Winter production helps them retain CSA members because there's no gap; customers get a share 52 weeks per year. The most convenient thing for their customers is to keep subscribing. Polly and James would rather farm than spend a lot of time marketing or looking for new customers, and this year-round relationship with members helps them sell nearly all their shares to existing customers.

They haven't evaluated the profitability of their winter vegetables specifically because they are so tightly integrated into their overall business. Their year-round CSA business model is profitable. They earn more per acre than most farms in their area.

Winter vegetables keep Polly, James, one full-time worker and a part-time worker employed year-round. It's always been part of Polly and James' vision to earn their living from the farm without having to rely on off-farm income.

Polly and James grow a wide range of vegetables so that their CSA shares have a lot of variety every week. Winter vegetables include purple sprouting broccoli, overwintering cauliflower, cabbage, kale, collards, Brussels sprouts, chard, radicchio, celeriac, carrot, parsnip, rutabaga, table beet, turnip and leeks. They also

grow lettuce, spinach, arugula, corn salad and bok choy in high tunnels. Newer crops include Hamburg parsley, early radish (February to March), celery (until December) and cilantro in the field. Most of their crops are grown and stored in the field, but they store carrots and celeriac in the cooler to reduce root maggot damage. Sometimes they do a rush harvest of crops like table beet and cabbage if there is a quick drop in temperature with no snow.

They look for hardy, tasty and productive varieties. They work closely with their seed companies and attend OSU Extension variety field days whenever they can. Every year they try out new varieties on their farm. Osborne Quality Seed, Territorial Seed Company and Johnny's Selected Seeds have all been very helpful over the years.

Leeks are their most important winter crop because they can tolerate any cold snaps local weather can throw at them. They mainly use cover crops and compost as soil amendments and have increased soil fertility in their fields over time. They've recently started working with OSU Extension and Concentrates, Inc. on fertilizer recommendations and now add some feather meal as a result. Results from an OSU Extension project show that they are supplying about the right amount of nutrients for their crops this way.

They irrigate leeks the same as their other crops with their automatic drip irrigation system. They are farming on relatively fine silt loam soil (Cornelius, Kinton and Laurelwood silt loams). Typically, they run one line of t-tape per bed, and crops get two hours per day with low-flow, 12-inch emitter spacing.

They start leek seedlings in the greenhouse in February and transplant them to the field in late May or early June. They dibble the beds about 4–6 inches deep and drop the seedlings into the holes. They water in the seedlings by hand with a wand and sometimes the seedlings get buried at first, but they emerge quickly. Planting into a hole blanches the lower stem and helps to produce high-quality leeks with a long white stem. The planting process is a three-person job and takes quite a lot of time. The leeks grow all summer and into the next winter. Their leeks have never been killed during the winter, even when it got down to 5°F (a historical low), and they had to chisel frozen soil to harvest the leeks.

Polly and James strongly recommend winter vegetables to other farmers, but advise careful planning. Succession planting strategies used in summer vegetables don't work with winter crops. All varieties of each type are planted at about the same time so they size up for the winter. In the case of brassicas, they are harvested when each variety matures in late winter and spring. They recommend preparing beds and starts for most winter vegetables in July and August, which is already a busy time of year for summer crops.

Photo: Neil Bell, © Oregon State University
Figure 39. The basket from Pumpkin Ridge Gardens CSA share shows the bounty of winter vegetables.

Heading brassicas and some other winter vegetable crops take a lot of space. Polly and James use 18-inch x 18-inch spacing in general, 12-inch x 12-inch for celeriac and radicchio, and 9-inch x 9-inch for leeks. Be sure to allow space for them. Polly says, "There's nothing like seeing purple-sprouting broccoli or winter cauliflower reach maturity in late winter after all you've had for a while is leafy greens and root vegetables."

Insect and disease damage can get worse over the winter. Some varieties are difficult to find because winter vegetables are a niche product and many seed companies don't offer them.

Polly and James see a lot of potential in local winter vegetables and encourage other farmers to tap into the market. Winter vegetables work very well with their CSA model, but there are also other markets for fresh, locally grown winter vegetables, including restaurants, farmers markets and direct to retail.

Photo: Lane Selman, © Oregon State University
Figure 40. Laura Masterson of 47th Ave Farm standing in a field of cover crops. Laura has been growing winter vegetables for the past 15 years.

47TH Avenue Farm

Laura Masterson first started growing winter vegetables for herself about 15 years ago and loved them so much that she added a winter share to her CSA offerings. She founded 47th Ave. Farm in 1997 and now farms at two locations: Lake Oswego and Grand Island, Oregon. Her first winter CSA shares were small and were distributed once a month, but they were so popular that she has been expanding them ever since. Her winter crops include collards, kale, chicory, cabbage, Brussels sprouts, turnips, kohlrabi, rutabaga, beets, celeriac, potatoes, carrots, leeks, radish, onions, shallots, garlic, winter squash, parsnip, purple-sprouting broccoli, cauliflower and broccoli raab.

47th Ave. Farm's winter share is a key component to the farm's viability because it helps to retain farm crews, CSA members and restaurant customers. Winter vegetables also provide winter and early spring income. Year-round work is more appealing to employees than seasonal work. Year-round crops also keep customers interested throughout the year. Laura originally thought shareholders would want to be year-round members. However, some customers only sign up for winter shares or summer shares because of their lifestyles. Multiple options give her customers more flexibility.

In general, winter vegetables pencil out financially for 47th Ave. Farm. Laura and her crew track the cost of production for all of their vegetable crops. Winter vegetables are more profitable than some summer crops and less profitable than others. At 47th Ave. Farm, winter crops have to be hand-harvested and hauled to the packing shed with large hand carts because their farm tracks are impassable for vehicles in the winter. Cold, wet, muddy conditions make harvest and handling more labor-intensive. They interseed cover crops into winter vegetables in September to provide ground cover and reduce mud problems.

Some of their winter crops are stored in refrigerated coolers, which increases energy costs. For example, a

rutabaga harvested and sold in October has a lower cost than a rutabaga that is harvested in October and refrigerated for two to three months before being sold. There are also some losses in storage, and Laura notices that the flavor also starts to decline in storage. In most cases, crops that are harvested and sold right away are more profitable than stored crops. Laura aims to harvest half of the storable crops in October or early November and leave half in the field for winter harvest. Winter crops have higher labor and storage costs, so Laura charges a bit more for them.

Laura works closely with seed companies to trial different varieties on her farm. Her top priority is flavor, followed by agronomic qualities like disease and insect resistance, cold hardiness and harvest windows. In the summer, Laura fertilizes winter crops at half the crop nitrogen requirement. On her farm, this is about 50–60 lbs plant-available nitrogen per acre. Crops are irrigated an inch a week until the winter rains begin in September or October, then irrigation is halted. Overwintering brassicas are targeted for a mid-to-late July transplanting so that they are about three-quarters full size by early November. Laura has noticed if heading crops are planted too late, they won't form marketable heads. Leafy greens like collards and kale are more forgiving and can be planted a little bit later than heading brassica crops.

Some of her farm's greatest successes with winter vegetables have been due to their excellent flavor. She says "winter carrots are the most delicious things on the planet. Overwintered cauliflower is the bomb and there are very few pests. With the right variety, right planting timing and right weather, there's a beautiful shining light of ripe cauliflower at the end of a long winter."

If you are interested in growing winter vegetables, Laura strongly recommends that you understand your market and check whether your customers want winter vegetables. Carefully consider whether you have enough acreage for winter vegetables and room to rotate all the brassicas. Also make sure you have enough labor at the right time, especially during transplanting and harvest.

Photo: Nick Andrews, © Oregon State University
Figure 41. Laura Masterson is experimenting with cover crop interseeding in late fall and winter vegetables. This lana vetch was interseeded into fall cabbage and was well established by mid-November. It grew into an excellent cover crop by the following spring.

Winter vegetables are a great way to extend the growing season if you want to do that.

Laura believes there is potential to expand the winter vegetable market. "People need to eat all year, and a lot of people don't yet know how fabulous and delicious winter vegetables are." She adds that "winter vegetables make sense for direct market growers at the small to mid-size farm range, but you need to be careful. Cash-flow and retention of customers and crew is good, but it is challenging and hard work."

Chapter 5

Health benefits of winter vegetables

Fresh vegetables are an important part of a healthy diet. They are good sources of dietary fiber, vitamins, minerals and other health-promoting compounds. They are also low in calories, saturated fats and carbohydrates (simple sugars), which contribute to chronic disease risk. In short, fresh vegetables are nutrient-dense and they promote good health.

Eating fresh vegetables promotes health and decreases the risk of chronic diseases, such as certain cancers, diabetes, heart disease and high blood pressure. The *2020-2025 Dietary Guidelines for Americans* recommend that the average adult eat 1 1/2 cups of vegetables per day. These guidelines encourage consumption of dark green, red, orange and starchy vegetables, including leafy greens, broccoli, Brussels sprouts, cabbage, carrots, turnips and others.

Health-conscious consumers purchase vegetables for themselves and their families and may be interested in nutritional information about these foods. Several credible online resources provide basic nutrition information that can be shared with customers, including the Academy of Nutrition and Dietetics Eat Right website, the USDA Center for Nutrition Policy and Promotion's My Plate website, and the USDA's Nutrition website. Also, see the "Resources" section of this publication.

Table 3 provides information regarding the health benefits associated with specific nutrients contained in the allium, heading brassica, leafy green and root vegetable categories. Additional information on the health benefits can be found at the resources listed above.

Table 4 provides information regarding the amount of calories, fiber, and vitamins A, C and K contained in typical serving sizes of the individual vegetables. This data is available online at the USDA Food Data Central database. Percent Daily Values (%DVs) have been calculated for each vegetable based on a 2,000-calorie daily diet. A food is considered a good source of a particular nutrient if the %DV is 10 or more, and an excellent source if the %DV is 20 or more. Some of the more common antioxidants present in the vegetables are also listed in the table.

Table 3. Physiological functions of dietary fiber, vitamins A, C and K

Nutrient	Function in the body
Dietary fiber	▪ Increases satiety levels and lowers food intake. ▪ Aids digestion and normalizes bowel movements. ▪ Decreases risk for colon cancer, diabetes and heart disease.
Vitamin A	▪ Essential for vision, including night vision. ▪ Aids cell and tissue growth. ▪ Strengthens the immune system. ▪ As an antioxidant, vitamin A may decrease risk for certain cancers, heart disease and other diseases. Note: Beta-carotene can be converted to vitamin A in the liver.
Vitamin C	▪ Heals wounds. ▪ Strengthens the immune system. ▪ Builds and maintains collagen that holds cells, bones and tissues together. ▪ Facilitates iron absorption. ▪ As an antioxidant, vitamin C may decrease the risk for certain cancers, heart disease and other diseases.
Vitamin K	▪ Helps blood clot. ▪ Promotes bone health.
Antioxidants	Antioxidants may prevent or delay some types of cell damage that are linked to the development of chronic diseases, including Alzheimer's, certain cancers, diabetes, heart disease, hypertension and macular degeneration. Research into these potential benefits is ongoing.

Sources: U.S. Food & Drug Nutrition Education Resources & Materials, Mayo Clinic Drugs & Supplements searchable database and National Institutes of Health Office of Dietary Supplements.

Table 4. Crop-specific dietary and nutritional information[1]

Crop (raw unless noted)	**Serving size**[2]	**Calories**	**Fiber** (g) % DV[3]	**Vit A** (mcg RAE[4]) % DV	**Vit C** (mg) % DV	**Vit K** (mcg) % DV	**Antioxidants**[5]
ALLIUMS							
Garlic	1 clove (3g)	4.5	<1	<1	<1	<1	Al
Leeks	1 medium (89g)	54	1.6 6%	444 49%	10.7 12%	41.8 35%	B-c, L, S, Z
Onion	1 small onion (70g)	28	1.2 4%	0	5.2 6%	<1	B-c, L, S, Z
HEADING BRASSICAS							
Brussels sprouts	1 cup whole (88g)	37.8	3.3 11.8%	192 21%	74.8 83%	156 130%	B-c, Is, L, S, Z
Cabbage	1 cup shredded (70g)	17.5	1.75 6%	3.5 < 1%	25.6 28%	53.2 44%	B-c, Is, L, S, Z
Cauliflower	1 cup chopped (90g)	25	2 7%	0	48 53%	15 13%	S
Sprouting broccoli	1 cup chopped (100g)	34	4 14%	100 11%	110 122%	185 154%	An, B-c, In, S, L, Z
LEAFY GREENS							
Arugula	2 cups chopped (40g)	10	<1	284 32%	6 7%	43.4 36%	B-c, L, Z
Beet greens	1 cup chopped (38g)	8.4	1.4 5%	120 13%	11.4 13%	152 127%	B-c, L, Z
Chard	2 cups chopped (72g)	14	1	110 12%	10.8 12%	299 249%	B-c, L, Z
Collards	1 cup chopped (36g)	11.5	1.4 5%	543 60%	12.7 14%	157 131%	B-c, Is, L, S, Z
Endive	1 cup chopped (50g)	8.5	1.6 6%	326 36%	3.2 4%	115.6 96%	B-c
Escarole	2 cups chopped (85 g)	15	3.0 10%	NA	3.3 4%	210 175%	B-c
Kale	1 cup chopped (50g)	24.5	1.8 6.4%	769 85%	60 67%	352 293%	B-c, L, Z
Mizuna[6]	2 cups chopped (85g)	10	<1	600 67%	12 13%	NA >100%	B-c, L, Z
Mustard greens	1 cup chopped (56g)	15	1.8 6.8%	507 56%	39.2 44%	144 120%	B-c, L, Z
Radicchio	1 cup chopped (40g)	9.2	<1	NA	3.2 4%	102 85%	B-c, L, Z
Spinach	1¾ cups chopped (50 g)	11.5	1.1 4%	469 52%	14 16%	242 202%	B-c, L, Z
LEGUMES							
Fava beans (cooked)	½ cup whole (90g)	98	4.9, 18%DV	<1	<1	2.6, 2% DV	B-c

Crop (raw unless noted)	Serving size[2]	Calories	Fiber (g) % DV[3]	Vit A (mcg RAE[4]) % DV	Vit C (mg) % DV	Vit K (mcg) % DV	Antioxidants[5]
ROOT VEGETABLES							
Beet	One 2" diam. (82g)	35.3	2.3 8%	1.6 < 1%	4 4%	<1	B-c
Carrot	1 medium (61g)	25	2 7%	509 57%	4.3 5%	9.5 7%	B-c, L, Z
Celeriac	1 cup chopped (156g)	65.5	2.8 10%	0	12.5 14%	64 53%	L, Z
Parsnip	½ cup sliced (67g)	50	3.5 12%	0	12 13%	15 13%	L
Rutabaga	1 cup chopped (140g)	51.8	3.2 11%	0	35 39%	<1	B-c, L, Z
Turnip	1 small (61g)	17	1.1	0	12.8 14%	<1	S

[1] Adapted from USDA FoodData Central, and OSU Linus Pauling Institute's Micronutrient Information Center.
[2] Nutrient content is based on fresh weight; volumes shown in the table are estimates only.
[3] % DV refers to percent daily value.
[4] RAE refers to retinol activity equivalents.
[5] Abbreviations for antioxidants. Al = allicin; An = anthocyanin; B-c = beta-carotene; In = indoles; Is = isothiocyanate; L = lutein; S = sulforaphane; Z = zeaxanthin.
[6] Adapted from What is mizuna? All about this unique, leafy green.

Following are some short nutritional and health promotion profiles for each crop type that are based on the information in tables 3 and 4. Please note that people taking blood thinners should consult with their physician before increasing their consumption of vegetables with high vitamin K content.

Alliums, including garlic, leeks and onions, are rich in sulfur-containing compounds that may act as antimicrobials and also help to decrease the risk for certain cancers and heart disease. Leeks are a standout, as they contain significant amounts of vitamins A, C and K. Leeks and onions also contain the antioxidants *beta*-carotene, lutein, and zeaxanthin. *Beta*-carotene is associated with a decreased risk of certain cancers and heart disease. Lutein and zeaxanthin are also associated with a decreased risk of macular degeneration.

Heading brassicas, including purple-sprouting broccoli, cabbage and Brussels sprouts, contain large amounts of dietary fiber, as well as vitamins A, C and K. Heading brassicas are also sources of the antioxidants *beta*-carotene, indoles, isothiocyanates and sulforaphane, which have been shown to have anticancer effects. They also provide lutein and zeaxanthin, which are associated with a reduced risk for macular degeneration. The purple color in purple sprouting broccoli indicates the presence of anthocyanins, known to promote heart health.

Leafy greens, including kale, collards, spinach and chard, are low in calories, contain dietary fiber and are good sources of vitamins A, C and K. These vegetables also contain the antioxidants *beta*-carotene, lutein and zeaxanthin. *Beta*-carotene is associated with a decreased risk of certain cancers and heart disease. Lutein and zeaxanthin are associated with a decreased risk of macular degeneration.

Fava beans, also known as broad beans, are high in dietary fiber and protein. They are also good sources of nutrients not listed in tables 3 and 4, including folate and iron.

Root vegetables, including carrots, parsnips, celeriac, turnips, rutabagas and beets, are low in calories, high in dietary fiber and are a good source of vitamins C and K. Carrots are also high in vitamin A and the antioxidant b*eta*-carotene. Turnips are a good source of calcium, and turnips, parsnips and rutabagas are good sources of potassium. These vegetables are also sources of the antioxidants lutein and zeaxanthin, which are associated with a decreased risk of macular degeneration.

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