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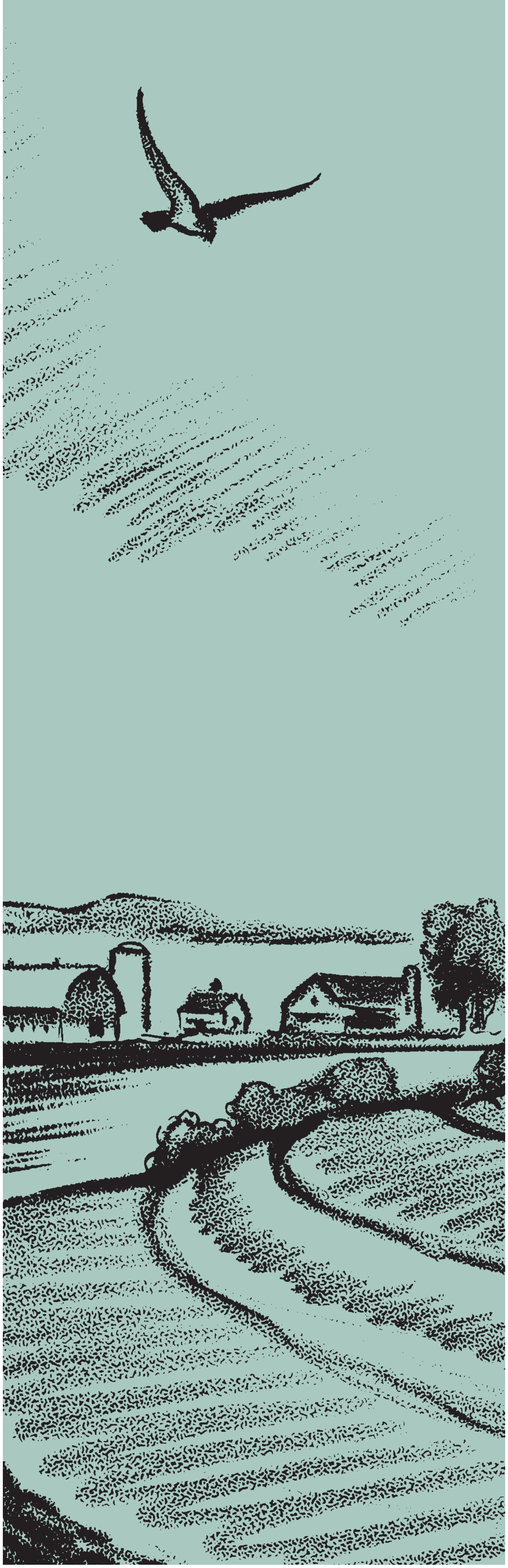

Growing beans and peas in Wisconsin

A guide for fresh-market growers

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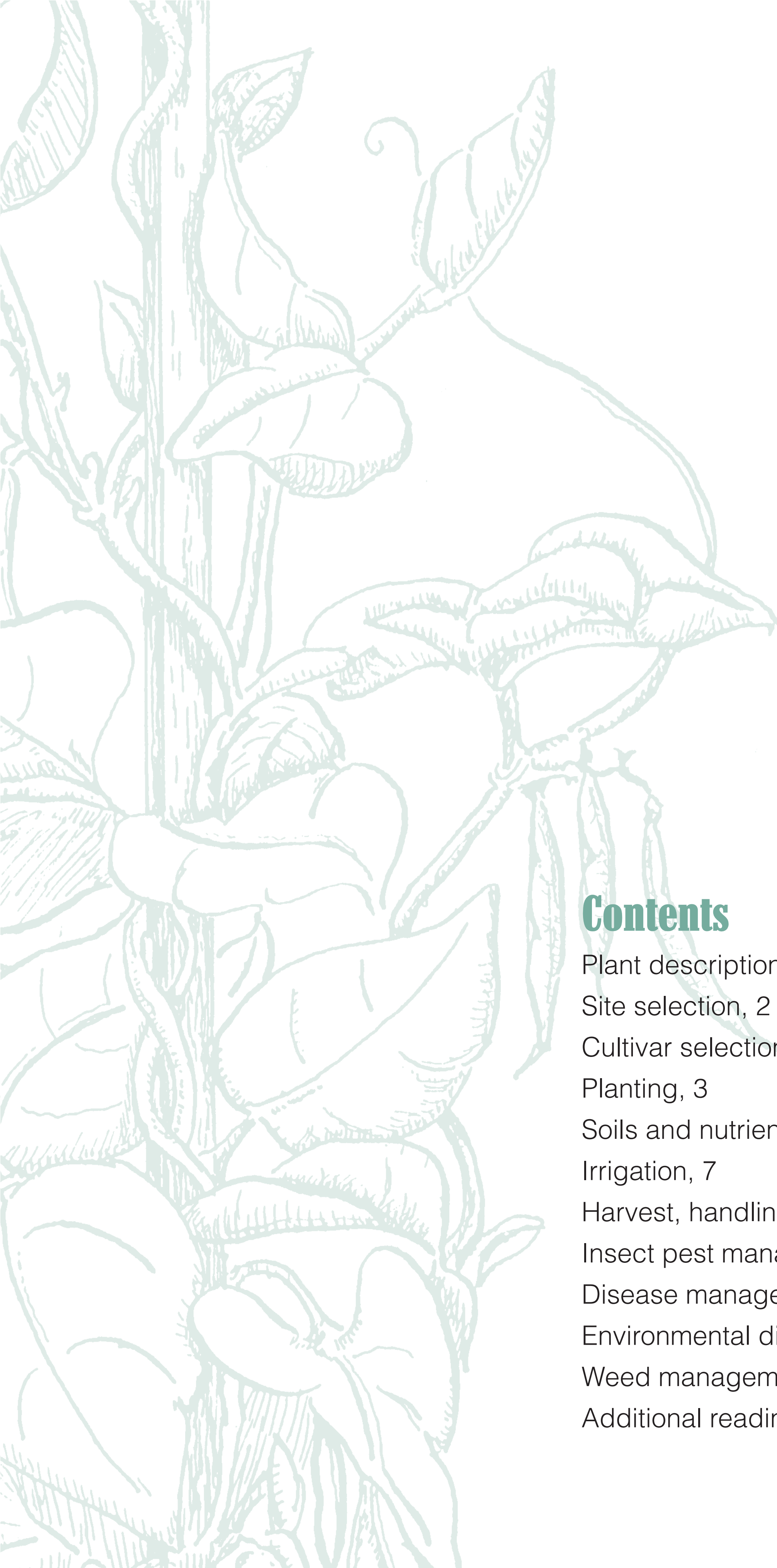
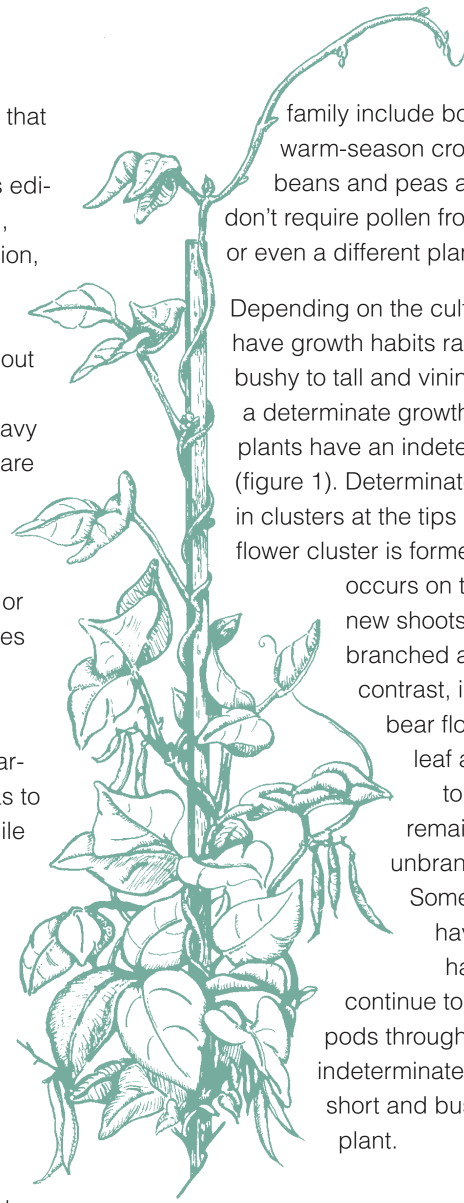


Contents

Successful fresh-market gardening involves more than just a talent for growing high-quality vegetables. You also need to find a market for them. Before you start, visit other growers, develop a marketing plan, and evaluate the feasibility of your proposed business. Think about what is unique about your product. Are you promoting the product for taste, freshness, health benefits, value-added, or time of availability? For assistance determining your market, consult with your county Extension agent or refer to Extension publication *Direct Marketing of Farm Produce and Home Goods* (A3602).



Beans and peas are popular vegetables that provide a good source of protein and carbohydrates. Specialty peas such as edible pod peas are available early in the season, before many of the staple vegetables. In addition, legumes such as beans and peas play an important role in the crop rotation system by providing nitrogen to the successive crop without the added expense of supplemental fertilizer. This is particularly important when growing heavy feeders such as sweet corn. Beans and peas are easy to grow and suffer relatively few disease and insect problems. The biggest obstacle growers must overcome is managing the high cost of harvesting by hand. Planting specialty or gourmet cultivars which command higher prices may help to offset the extra expense of hand picking.

This publication describes how to grow and harvest snap beans, lima beans, and garden peas to help fresh market growers maximize yields while minimizing production costs. It covers cultivar selection, fertility and irrigation needs, and potential insect and disease problems. Dried peas and beans, which have different growth and harvesting considerations, are not discussed in this publication.

Plant description

Common snap beans (*Phaseolus vulgaris*) and lima beans (*Phaseolus lunatus*) originated in Central America, while the garden pea (*Pisum sativum*) can be traced back to middle Asia.

Beans and peas are members of the legume family. Legumes have several unique features. They provide an important source of protein, and they use the atmospheric form of nitrogen (N_2) for growth and development. Most other plants require soil nitrogen in either the nitrate (NO_3^-) or ammonium (NH_4^+) form.

Most legumes are herbaceous annuals. Technically, large-seeded lima beans are classified as tender perennials, but they are grown as annuals.

The members of this family include both cool-season and warm-season crops. The flowers of beans and peas are self-fertile; they don't require pollen from a different cultivar or even a different plant to produce pods.

Depending on the cultivar, beans and peas have growth habits ranging from short and bushy to tall and vining. Bushy plants have a determinate growth habit while vining plants have an indeterminate growth habit (figure 1). Determinate plants bear flowers in clusters at the tips of shoots. Once a flower cluster is formed, no further growth occurs on that shoot. Instead, new shoots form, creating a branched and bushy plant. By contrast, indeterminate plants bear flowers (and fruit) in the leaf axils. Shoots continue to grow and the plants remain relatively unbranched and vining. Some varieties of beans have an intermediate habit. These plants will continue to set blossoms and pods throughout the season like an indeterminate plant, but will remain short and bushy like a determinate plant.

Figure 1. Determinate plants (left) form flowers at the ends of branches while indeterminate plants (right) produce flowers in leaf axils.

Site selection

When selecting a planting site, choose a sunny location. Well-drained sandy loam soil is best. Heavy soils remain too cool and wet, conditions that slow germination of snap beans and lima beans and predisposes peas to root rot diseases. By contrast, sandy soils warm up quickly but they do not hold water and crops will need to be irrigated during dry weather.

Legumes should be planted in a different location each year to prevent the buildup of root rot pathogens. Ideally, allow 3 to 4 years before planting legumes back into a site.

Soil pH should be neutral to slightly acidic provided all nutrients are readily available.

Cultivar selection

Beans

Early snap bean cultivars were referred to as string beans because of the fibrous strands which ran the length of the pod. Today, plant breeders have developed varieties without the fibrous strands. Bean cultivars are classified as either pole or bush. Bush beans may be categorized as filet or snap beans. Filet, or French-style beans, are snap beans with flattened pods. All pole beans are characterized as snap beans. Wax beans are also classified as bush or pole types.

Bush beans

Green: Bush Blue Lake 274, Bush Romano, Contender, Derby, Greencrop, HyStyle, Provider, Top Crop

Wax: Cherokee, Goldcrop, Goldrush, Pencil Pod

Lima: Henderson, Thorogreen

Pole beans

Green: Blue Lake, Kentucky Blue, Kentucky Wonder, Kentucky Wonder 125, Romano, Trionfo (purple pod)

Lima: King of the Garden

Specialty beans

Filet: Camile, Dandy, LaBelle, Maxibel, Triumph de Farcy, Vilbel, Vernandon

Purple: Royal Burgundy, Sequoia

Other: Scarlet Runner

Peas

Peas are classified by growth habit, pod appearance, seed color, and whether the seed is starchy or sugary. Pea cultivars grown for once-over harvest are primarily determinate, wrinkled and sugary with blunt-ended pods. Edible pod peas, which have become popular in recent years, are usually indeterminate with a flattened pod and very small sugary seeds.

Dwarf: Alaska, Early Frosty, Freezonian, Green Arrow, Lincoln, Thomas Laxton, Wando

Tall: Alderman

Edible pods (also called Chinese or Snow): Blizzard, Dwarf Gray Sugar, Mammoth Melting Sugar (tall), Oregon Giant, Oregon Sugar Pod II (dwarf)

Edible (thick-walled pods): Sugar Ann (dwarf), Sugar Snap (tall)

Other: Novella II (semi-leafless), Pink-eyed Purple Hull (southern)

Planting

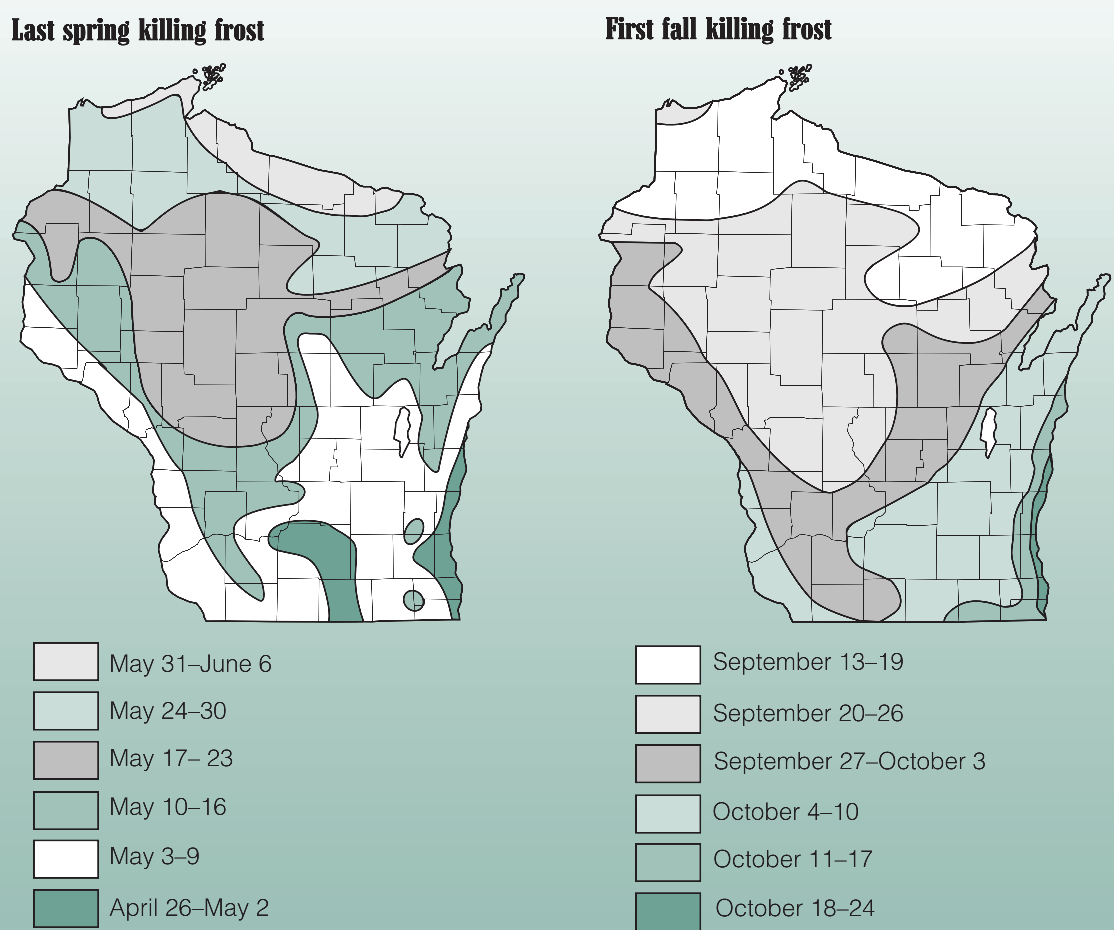
Soil preparation. For early peas on sites where erosion is negligible, prepare the planting site the previous fall. Preparing the soil in the fall will prevent any planting delays caused by cold, wet soils and will help reduce soil compaction associated with working wet soils. Compacted soils restrict root growth, reduce the amount of oxygen available to roots, and limit water penetration, all of which can hurt yield potential. Work beds 6–7 inches deep to promote good rooting.

Raised beds. Raised beds are an alternative to the conventional field planting method. They improve soil drainage and allow access to the crop without causing soil compaction. Raised beds are typically 4–5 feet wide and 100 feet long. The width is determined by the type of equipment used and by the crop. Leave a 1-foot aisle on either side of each bed to accommodate foot traffic.

Planting dates. Peas are a cool-weather crop and can be planted as early as April 15 in southern Wisconsin. Northern Wisconsin gardeners should delay planting until May 1.

Do not plant beans until after the date of the last expected frost (figure 2). In southern Wisconsin, this is typically around May 20. In northern Wisconsin, wait until late May or early June to allow for adequate warming of the soil. Snap beans need a minimum soil temperature of 50°F for proper germination and growth while lima beans require a soil temperature of 65°F. Lima beans also require warmer temperatures

Figure 2. Approximate dates for first and last killing frosts.



than snap beans to thrive. Three to four months of warm day and night temperatures are necessary for proper development of lima beans. Sequential plantings may be made at 2-week intervals through midsummer. Check the seed package to determine how many days are necessary between germination and harvest. Count back from the average first fall frost date (figure 2) in your area to determine the appropriate last planting date.

Seeding information. Both beans and peas benefit from soaking the seeds for an hour in water and then shaking legume inoculant powder on the moist seeds just before planting. All legumes are direct seeded. Small-scale fresh market growers often use a walk-behind seeder which has interchangeable plates to plant each type of seed. Table 1 provides information on how much seed you'll need and recommended spacing for plants and rows. Both peas and beans may be planted in double rows to maximize yields and use garden space efficiently. When planting peas in double rows, space seeds 1–2 inches apart, space double rows 6 inches apart, and space pairs of rows 18–24 inches apart. For bush beans, space seeds 2 inches apart, space double rows 9–12 inches apart, and space pairs of rows 18–24 inches apart. For pole beans, space seeds 3–4 inches apart, space double rows 12 inches apart, and space pairs of rows 36 inches apart.

Support structures. Peas and pole beans require support. Install support structures at planting. A variety of trellis materials, such as nylon mesh, twine, and wire fencing all work well. Each grower should assess the cost of materials, labor availability, and return on investment to determine the best support structures for their operation.

Pea trellises are made of different materials, depending on whether the peas are short (grow to 3 feet) or tall (grow to 6 feet). Short trellises can be constructed using 1 x 2 inch wooden stakes 4 feet long pounded 1 foot into the ground. Place stakes 10 feet apart. Knot a length of strong cotton twine 6 inches above ground level, then loop it around the second and each sequential stake until the end of the row and knot it to the last stake. Repeat this process until you have a 3-foot high trellis with six strings spaced 6 inches apart.

Construct a tall pea trellis by setting 10-foot stakes, 2 x 2 inches, or saplings 18 inches deep. Place stakes 8 feet apart. Fasten 6 foot wide nylon netting with 6 x 6 inch mesh to the stakes by stapling, using vinyl tape, or plastic electrical wire ties. Fasten the mesh to the top, middle, and bottom of each stake. At the end of the growing season it is easier to remove dead vines from nylon mesh (to reuse it) than it is from chicken wire fencing.

Table 1. Planting guide

Vegetable	Planting time, outdoors in southern WI[a]	Seeds needed for 100 ft of row	Spacing (inches)[b,c]		Days to first harvest[d]	Estimated yield (lb/ft of row)[e]
			Between rows	Between plants		
Bean, bush lima	May 25	8 oz	24–30	3–4	70–80	0.30
Bean, bush snap	May 10	8 oz	18–24	2–3	50–60	0.50
Bean, pole snap	May 10	6 oz	30–36	3–4	60–65	0.70
Pea	April 15	1 lb	15–18	1–2	60–70	0.25–0.50

[a]Plant about 1 week later along the lower lake shore and in the central part of state and about 2 weeks later in northern counties.

[b]Plant bean and pea seeds 1 inch deep.

[c]If using a plate-type seeder, spacing between plants will be determined by plate configuration.

[d]Cultivars vary greatly in time needed to reach harvest stage; extend the harvest season by planting cultivars of different maturity dates or by making successive plantings of the same cultivar.

[e]Estimated yields under less than ideal growing conditions; actual yields will vary widely with weather, soil fertility and cultural practices.

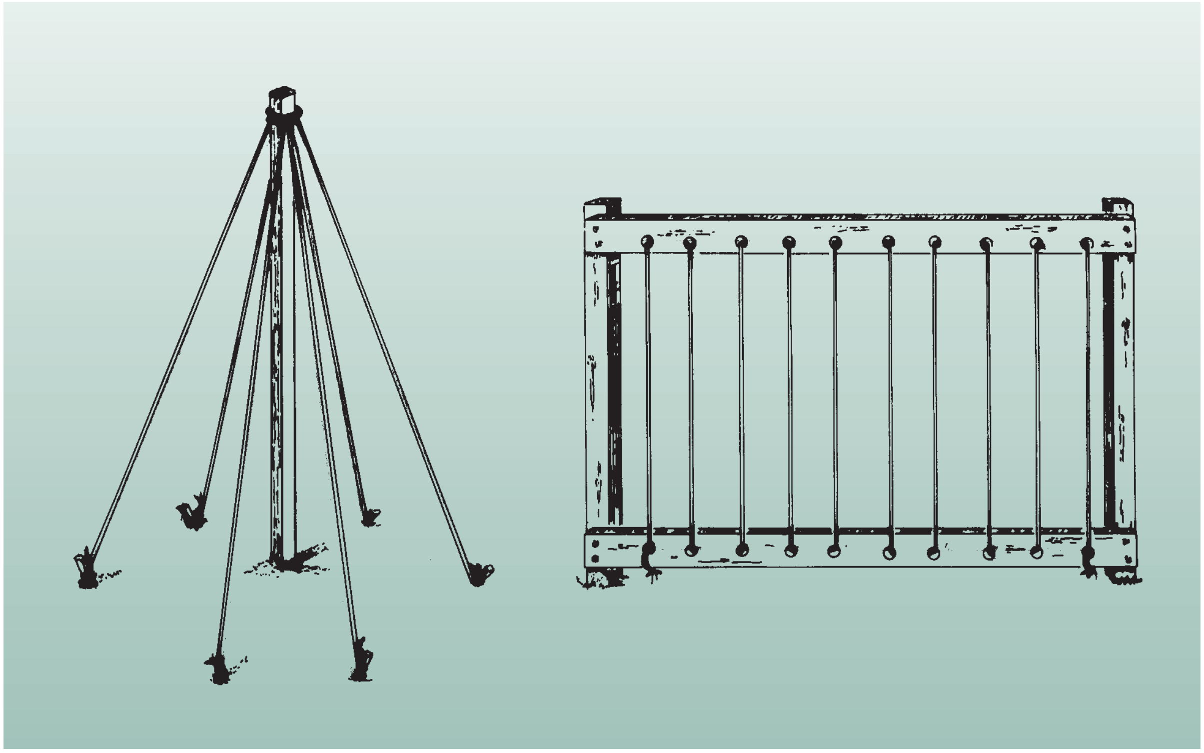


Figure 3. Teepee and rectangle support structures for pole beans.

Pole beans require sturdier supports than peas. Pole beans will twine around 6–8 foot stakes made of 1 x 1 inch wood, saplings, bamboo, or pipe. You can build any of a variety of frameworks, such as a teepee, an A-frame, or a rectangle to support pole beans (figure 3).

Soils and nutrient management

Obtain a soil test for available nutrients before planting a field for the first time and routinely thereafter at least once every 3 years. After 3 years, soil conditions can change enough to make your current fertility management program obsolete. For information on how to collect good samples and where to send them for analysis, see Extension publication *Sampling Soils for Testing* (A2100).

Routine soil tests include pH, organic matter content, phosphorus and potassium. Special tests are available on request for nitrate-nitrogen, calcium, magnesium, sulfur, boron, manganese, and zinc. You will receive the results of your soil test along with fertilizer recommendations based on your cropping history and planned use of the field.

Soil pH. Soil pH should be maintained near 6.8 on mineral soils and 5.6 on organic soils to maintain the availability of micronutrients and reduce root rot disease pressure, especially on snap beans.

Nutrients. Plants take up nitrogen as nitrate (NO_3^-) or ammonium (NH_4^+), phosphorus as phosphate (P_2O_5), and potassium as potash (K_2O). These chemicals, as fertilizers, can come from organic or inorganic sources. With adequate environmental conditions, soil microbes break down organic matter and supply the chemicals that plants need to their roots. Organic fertilizers can also improve soil tilth and health. Inorganic fertilizers can be used to quickly supply nutrients to plants.

Organic fertilizers can come from a variety of sources such as manures, compost, fish meal, and bone meal. Each material contains varying amounts of specific nutrients. Table 2 lists organic fertilizers and the amounts of nutrients in each. For more information on this subject, refer to Extension publication *Organic Soil Conditioners* (A2305).

Table 2. Nutrient composition of various organic fertilizers

Material	N	P_2O_5	K_2O
Alfalfa hay	2.0–3.0	0.2–0.6	2.0–3.2
Bone meal	0.2–1.0	12.0–14.0	—
Compost[a]	0.5–3.5	0.5–1.0	1.0–2.0
Fish meal	9.0–11.0	5.0–8.0	0.0–3.0
Greensand	—	—	7.0
Manure, cow	0.5–0.7	0.2–0.4	0.5–0.8
Manure, sheep	1.0–2.0	0.7–1.0	0.5–2.0
Manure, poultry	1.1–1.7	1.0–1.3	0.5–1.0
Rock phosphate	—	20.0–30.0	—
Soybean meal	7.0	0.5	2.3

[a]Nutrient analysis of compost will vary based on the source.

Fertilizing beans. Beans are shallow rooted, early feeders. They need most of their nitrogen, phosphorus, and potassium at planting. On sandy soil, apply half the nitrogen when the first true leaves appear and half at bud stage. Prevent fertilizer from contacting the seed by banding it 2 inches to the side and 2 inches below the seed row. See table 3 for recommended fertilizer rates.

Beans grown in soils deficient in iron, manganese, and zinc will produce a lower yield than those grown in areas with adequate amounts of these nutrients. Lima beans are particularly sensitive to low levels of manganese. If you suspect a nutrient deficiency, you'll need to specifically request a tissue test to confirm the problem and then have the soil tested to determine the levels.

Fertilizing peas. Results from the soil test will help determine the need for phosphorus and potassium. On sandy soils it may be necessary to apply nitrogen prior to planting. Table 3 lists the recommended fertil-

Table 3. Annual nitrogen, phosphate (P_2O_5), and potash (K_2O) recommendations

	Nitrogen			Phosphate and potash				
	Organic matter	Amount to apply		Yield goal[a]	Amount to apply[b]			
					P_2O_5		K_2O	
Vegetable	%	lb/a	oz/100 sq ft	lb/a	lb/a	oz/100 sq ft	lb/a	oz/100 sq ft
Snap beans	<2.0	60	2.2	5001–7000	15	0.48	30	1.1
	2.0–4.9	40	1.5	(11–16 lb/100 sq ft)				
	5.0–10.0	20	0.74					
	>10.0	10	0.37					
Lima beans	<2.0	60	2.2	3001–4000	30	1.1	60	2.2
	2.0–4.9	40	1.5	(7–9 lb/100 sq ft)				
	5.0–10.0	20	0.74					
	>10.0	10	0.37					
Peas	<2.0	40	1.5	2501–4000	15	0.48	30	1.1
	2.0–4.9	30	1.1	(6–9 lb/100 sq ft)				
	5.0–10.0	20	0.74					
	>10.0	10	0.37					

[a]The yield goal listed is the average range per acre. For higher or lower yield goals, consult the soil test recommendations.

[b]Amounts of P_2O_5 and K_2O are for optimum soil test levels. Apply half the given rate if the soil test is high and omit if the soil test is excessively high. If soil test is low or very low, increase rates according to the soil test recommendations.

izer rates for peas. Like beans, pea seeds are sensitive to contact with fertilizer. Starter fertilizer is especially important for early peas on cool, wet soils because nitrogen-fixing bacteria are less active. Peas are relatively tolerant of low levels of micronutrients. However, if boron is limiting, plants may become distorted and empty pods produced.

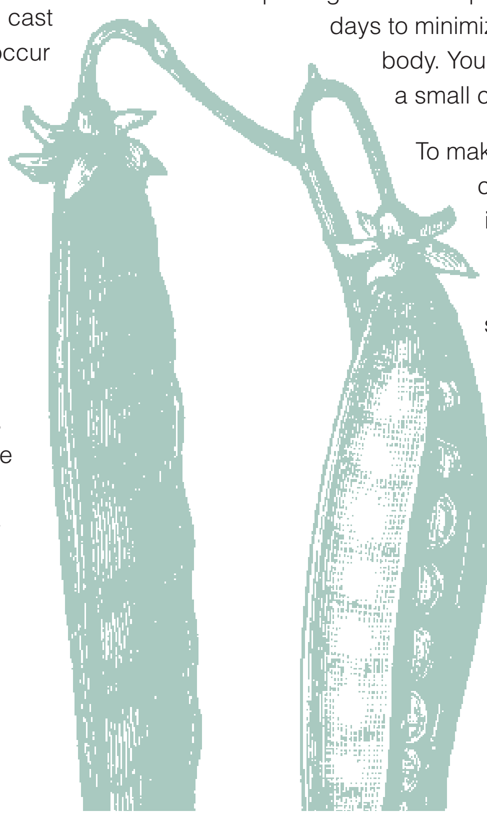
Irrigation

Moisture stress can reduce crop yields. If leaves begin to wilt mid-day, plants are moisture stressed. Both drip and overhead sprinkler irrigation systems are effective, such as trickle tape, solid set, and traveler hose wheel. Drip irrigation works particularly well with colored plastic mulch that is used as a season extender.

Irrigation scheduling software is available from the University of Wisconsin-Extension to help you determine your irrigation needs. For more information on this software, contact your county Extension agent.

Beans planted late in the season are at risk of moisture stress both before and after germination. If the soil becomes too dry prior to emergence, a crust will form and emerging seedlings will be damaged. During the remainder of the season, the soil must not be allowed to dry out. Moisture stressed bean plants tend to have a bluish cast to their foliage. Irrigation should occur within 3 to 5 days after this color change becomes apparent. Moisture stress during flowering and pod development will cause flowers and pods to abort.

Unlike beans, peas should not be irrigated during bloom. Irrigation during this stage will result in poor pod fill or pod drop. Irrigation should be resumed once flowering is complete. If peas get too much water late in their maturity, pods will crack.



Harvest, handling, and storage

Both beans and peas are ready to harvest when they are sweet, tender, and have uniform pod size and color. Beans and peas that are too large do not have good flavor.

Harvest beans by hand 14–18 days after full bloom. Rinse them for a few minutes in cool water immediately to reduce field heat and to remove dirt. Dry beans on a screen table, pack them into a waxed cardboard box, and store them in a cooler at 41°F and 95% humidity. They will keep in top condition for 5 days.

Harvest peas by hand 3 weeks after full bloom. A more reliable method of determining when to harvest peas is to calculate the accumulation of degree days (see sidebar, page 9). Pea cultivars mature once 1100–1600 degree days have accumulated. Use a base temperature of 40°F. Rinse and pack peas as for beans, but line the cardboard box with a damp cloth to provide evaporative cooling and keep peas fresh. Peas can be stored at 35–40°F and 85–90% humidity for up to 5 days.

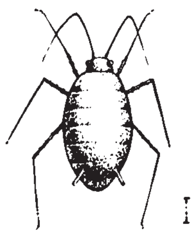
Arrange your harvest schedule so that the task of picking beans and peas is spread out over a few days to minimize stress and fatigue to your body. You might wear knee pads or sit on a small cart. Change your position often.

To make harvesting more efficient, consider using “batch” processing. For example, you could pick into a bucket which you then empty into a standard sized, vented plastic container lined with a mesh bag. Use a cart to transport the containers to the packing area, and dunk the entire mesh bag of produce into the wash tank at once.

Beans and peas are most often sold by the pound and placed in plastic produce bags.

Insect pest management

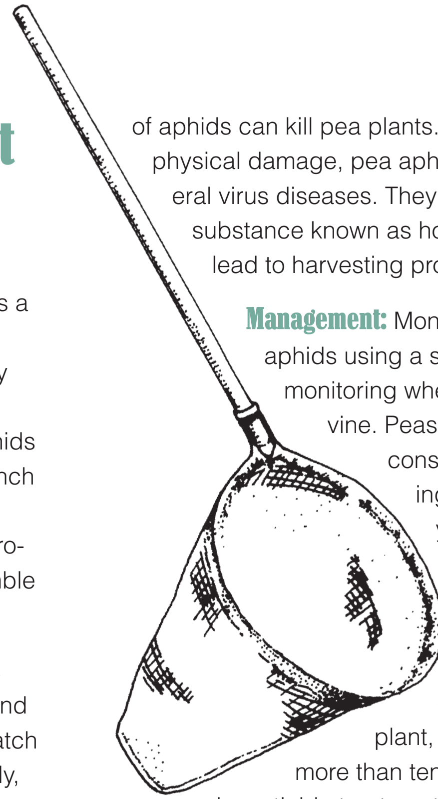
Pea aphid



Description: The pea aphid is a common pest of peas in Wisconsin. Aphids commonly migrate into pea fields from nearby alfalfa fields. Pea aphids are small, green insects (¼ inch long) with a pair of tubelike structures called cornicles projecting from the rear of their body. Nymphs resemble adults except they are smaller and lack wings.

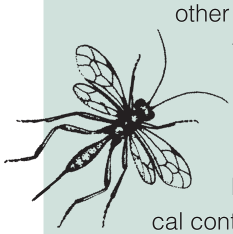
Life cycle: Pea aphids overwinter in Wisconsin as small black eggs on the stems of alfalfa, clover, and other legumes. In the spring, wingless females hatch from the eggs. These females reproduce asexually, giving birth to live young. The nymphs undergo four molts before becoming adults. In late May or June, winged adults migrate into pea fields from nearby alfalfa and other legume fields. As the season progresses and peas no longer provide adequate food supplies, winged forms again appear and migrate back into alfalfa. Late in the season, male aphids are produced. They mate with the females and provide genetic diversity. After mating, the females lay eggs which will survive the winter.

Damage/Symptoms: Aphids feed by sucking juices from plants. This feeding ruptures plant cells, causing wilting, stunting, and chlorosis. Large populations of aphids can kill pea plants. In addition to the physical damage, pea aphids can spread several virus diseases. They also excrete a sticky substance known as honeydew that may lead to harvesting problems.



Management: Monitor weekly for pea aphids using a sweep net. Begin monitoring when plants begin to vine. Peas appear to tolerate considerable aphid feeding and rarely sustain yield losses in Wisconsin. However, if you find more than 35 aphids per sweep, or 2 aphids per plant, *and* the peas are more than ten days from harvest, insecticide treatment is recommended. Stressed plants such as those in droughty conditions, are likely to experience significant impact from aphid feeding. Numerous predators and parasites of the pea aphid will normally help to keep populations in check unless broad-spectrum insecticides are used indiscriminately. Some of the more important natural enemies include syrphid flies, braconid wasps, lady beetles, and lacewings. These beneficial insects are often quite successful in reducing aphid numbers below damaging levels.

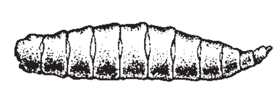
Conservation of natural enemies



Not all insects are pests. Beneficial insects prey on other insects, helping to keep populations in check. You can take advantage of this free natural resource by minimizing the use of broad-spectrum insecticides. For more information about biological controls, see Extension publication *Biological Control of Insects and Mites: An Introduction to Beneficial Natural Enemies and Their Use in Pest Management* (NCR481).

Seedcorn maggot

Description: Seedcorn maggots attack beans and a variety of other crops. Adult seedcorn maggots resemble small houseflies. They are dark gray, ⅕ inch long, and their wings are held overlapped over their bodies while at rest. The larvae are yellowish-white, ¼ inch long when fully grown, legless, and wedge-shaped with a pointed head. The pupae are brown, ⅕ inch long, cylindrical in shape, and rounded at both ends.



Life cycle: The seedcorn maggot overwinters as pupae in the soil. Peak adult emergence from the pupae occurs from early to mid-May when degree days have reached 200 DD using a base temperature of 39°F (see sidebar for information about degree days). After mating, the female lays her eggs in soils near the seeds and seedlings of a wide variety of plants. Eggs hatch in 2–4 days. Larval feeding, development, and pupation all occur below ground and the subsequent generation of adults appear 3–4 weeks later. There are 3–5 generations a season.

Damage/Symptoms: Seedcorn maggots are commonly identified as the culprit in vegetable plantings exhibiting poor stands. The larval seedcorn maggots destroy germinating seeds by feeding on the cotyledon leaves. Emerged plants may be severely stunted or may have damaged primary leaves or no leaves at all ("snakehead" seedlings). Fields with large amounts of organic matter are more attractive to the adult seedcorn maggots for egg-laying.

Management*:* There are several options for reducing the damage caused by seedcorn maggots. Avoid planting into fields with freshly incorporated organic matter since the adult flies prefer such sites. Delay planting for several days during the peak period for adult emergence. Tracking degree days will help you determine when to delay planting to reduce the likelihood of damage. Any practice that promotes fast germination and seedling growth will also reduce maggot damage. In areas with a history of severe maggot damage, treated seed may be necessary.

Calculating degree days

Temperature affects the rate of development of plants and insects. Cold weather slows development while warm weather accelerates it. For this reason it is misleading to describe development in terms of time alone. To monitor crop development and predict pest behavior, professional pest managers often use a system that takes into account the accumulation of heat with passing time. This system is based on degree days (DD).

A degree day (DD) is a unit of measure that occurs for each degree above a base temperature during a 24-hour period. The base temperature is the temperature below which there is no plant or insect development. Specific insects have specific base temperatures. Most plants use a base temperature of 50°F. Cool-season plants, such as peas, grow in cooler temperatures and have a base temperature of 40°F. Begin recording degree day accumulations for Wisconsin on March 1.

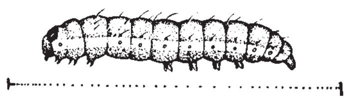
To monitor plant and insect development using degree days, you will need a maximum/minimum thermometer to obtain the daily high and low temperatures. Calculate degree days using the equations below.

Example: Assume you have accumulated 200 degree days to date using a base temperatutre of 40°F. If yesterday's high temperature was 75°F and the low temperature was 60°F, then the daily average temperature would be 67.5°F [(75 + 60) ÷ 2]. To calculate the degree day accumulation, subtract the daily average from the base temperature for a total of 27.5DD (67.5 – 40). Add this number to the total number of degree days to date (27.5 + 200) for a new total of 227.5.

(daily high[a] + daily low[b]) ÷ 2 = daily average temperature
daily average temperature – base temperature = degree day accumulation

[a]Use 86°F if the high temperature for the day is more than 86°F.
[b]If the daily low is less than the base temperature, use the base temperature.

Corn earworm



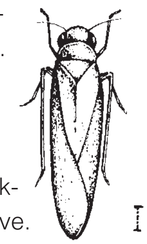
Description: Corn earworms can be an economically important pest of beans in Wisconsin. Adult corn earworms are grayish-brown moths with a wing span of about 1½ inches. The fore wings are marked with dark-gray, irregular lines with a dark area near the wing tip. The hind wings are white with dark spots or areas along the margins. The olive-brown larvae are 2 inches long and have three or four dark stripes along their back. The head is yellow and not spotted. The small yellowish, sculptured, hemispherical eggs are laid singly on the foliage or corn silks.

Life cycle: Few corn earworms overwinter in Wisconsin, and most migrate into the state annually from southern states. Corn earworms overwinter as pupa buried in the soil and complete their development in the spring. Adults emerge in early May and begin their northward migration. The moths fly mainly at dusk or during warm, cloudy days and arrive in Wisconsin in late July. After mating, females lay eggs individually; each fertilized female can deposit up to 1000 eggs during her lifetime. Larvae begin feeding immediately upon hatching. Development from egg to adult requires about 30 days in midsummer.

Damage/Symptoms: Larvae feed on both leaves and buds of snap beans, leaving holes in the plant tissue. The small larvae will feed directly on the pods, creating blemishes and causing pod rot. Larvae may also pose a contamination problem in snap beans grown for processing.

Management: Corn earworms are easily monitored with the use of Hartstack pheromone traps. Traps should be checked daily beginning in July. Treat vulnerable beans if there are five or more moths per trap per night. Snap beans should be sprayed every 5–7 days to control problem populations. Treat until 5 days before harvest.

Potato leafhopper



Description: Snap beans are very susceptible to potato leafhopper damage. These pests are small (1/8 inch), wedge-shaped, green insects with whitish spots on the head and thorax (upper body). They have piercing-sucking mouthparts and are extremely active. They commonly jump, fly, or crawl both forward and backward when disturbed. Nymphs look like the adults, but lack fully developed wings.

Life cycle: Potato leafhoppers don't overwinter in Wisconsin; they are blown into the state each spring on southerly winds. Large populations of leafhoppers migrate from alfalfa fields in June and early July causing populations to increase rapidly and seemingly "explode" overnight. Adult females insert white eggs into the stems or large leaf veins of susceptible crops. Each female lays approximately 3 eggs each day for about a month. The nymphs hatch 7–10 days later. They molt five times over a period of 12–15 days before turning into adults. There are normally two generations per year in Wisconsin and populations decline significantly in August.

Damage/Symptoms: Both the adults and the nymphs have piercing/sucking mouthparts and suck plant juices from green parts of plants, often giving leaves a whitened, mottled appearance. The first symptom of injury is a brown, triangular lesion at the leaflet tip. As symptoms develop, plants become stunted and yellow and the leaves curl upward at the margins. Premature death may occur in severe infestations. The burned appearance of the foliage gives the damage the descriptive name "hopperburn." Unfortunately, yield loss occurs even before the development of obvious symptoms. The plants may show little evidence of hopperburn, and yet the yield losses can be substantial.

Management: Healthy plants will withstand damage more effectively than stressed plants. Irrigation and cultural practices which favor snap bean growth are recommended. Infestations are more likely to occur in crops planted adjacent to alfalfa. If you find one adult leafhopper per sweep or one nymph per 10 leaves, insecticides will provide the only effective means of controlling these pests. If plants have fewer than two true leaves, treatment will be necessary if you find one adult per two sweeps.

Disease management

Peas are susceptible to several root rot pathogens. The most common organisms occurring in Wisconsin include *Pythium*, *Aphanomyces*, *Rhizoctonia,* and *Fusarium*. Symptoms of *Pythium* infection are most commonly observed at emergence while symptoms of *Aphanomyces*, *Rhizoctonia,* and *Fusarium* are most commonly observed later in the season, especially if cool, wet conditions prevail early in the season and the crop is stressed by heat and water fluctuations later in the season.

Beans are commonly plagued by bacterial diseases, including bacterial brown spot and halo blight. In addition, beans are very susceptible to *Sclerotinia* white mold.

Aphanomyces root rot

Description: *Aphanomyces* root rot is caused by a water mold. This fungus requires free water in order to spread through the soil. It is capable of infecting pea and snap bean plants at all stages of development.

Disease cycle: The fungus overwinters as thick-walled oospores in plant debris. Fields infested with *Aphanomyces* may remain unsuitable for planting susceptible crops for up to 10 years. In the spring, the fungus produces asexual zoospores. These spores are disseminated through soil water or by any practice that moves soil from one location to another. Plants are usually infected at germination.

Symptoms: Early symptoms appear as long, soft, water-soaked areas on the surface of the lower stem and root. Symptoms first appear 2 weeks after infection. As the disease progresses, these water-soaked areas become light tan and spread throughout the root system. The roots become slimy and dark, especially if the soil remains wet for several days at a time. Pods on infected pea plants may have only one or two peas and these are inclined to be large and irregularly shaped. Stems on bean plants may become soft and discolored or flattened and collapse above the soil line. In severe cases, infected plants will become yellow and shrivel before dying prematurely.

Management: Planting in well-drained soil is the best practice to reduce the occurrence of infection by *Aphanomyces*. Rotating out of legumes for at least 3 years will also reduce the chance of infection occurring. Proper fertilization and other cultural practices that improve the vigor of the crop will help plants overcome infection. Seed treatments with a suitable fungicide will also be effective in reducing infection. Once plants become infected, fungicide treatments are neither economical nor practical to use.

Pythium root rot

Description: *Pythium* root rot, also known as damping off, attacks peas and many other plants. This disease is caused by the water mold *Pythium*. It is so widespread that many growers overplant to ensure a good stand. The fungus can attack plants at any stage of development. Yield losses may reach 100%.

Disease cycle: *Pythium* species can survive in the soil for very long periods as resting oospores. Given cool, wet conditions the fungus produces zoospores which are capable of causing infection. Soils that remain wet for long periods favor the development of damping off.

Symptoms: The initial point of infection appears as a slightly sunken, water-soaked lesion. The fungus spreads up and down the stem producing a semi-soft, reddish to dark-brown rot. The pith of the stem may be destroyed, giving rise to the descriptive name "hollow stem." Stems are typically not soft or discolored, but may be flattened or collapsed from the soil line upward for a few inches. These symptoms are similar to those caused by *Aphanomyces*. Older plants may outgrow the fungus.

Management: It is important to test any soil suspected of having *Pythium* to determine the amount of inoculum present. Planting seeds in well-drained soils or raised beds will also reduce the likelihood of infection. Supplemental nitrogen will help induce the formation of adventitious roots above the area of decay, however excess nitrogen has been shown to contribute to disease losses. There are currently no fungicides available that offer effective control of this disease.

Fusarium root rot

Description: *Fusarium* root rot is another fungal disease. The disease can be severe in fields where beans or peas have been grown continuously, especially in soils that are too wet, too cold, or too hot for ideal plant growth. *Fusarium* root rot usually occurs during mid- or late season.

Disease cycle: The fungus that causes *Fusarium* root rot overwinters on infected plant debris or in the soil. It can remain viable in the soil for many years. It is capable of growing and reproducing on dead plant parts. Spores are disseminated by splashing water or by any means that moves soil from one location to another. The fungus enters the roots and infects the water transport system and the structural tissues.

Symptoms: Often the first symptom of *Fusarium* root rot is when one side of the plant wilts while the other side appears healthy. A slight reddish discoloration of the taproot appears 1 week or more after the seedling emerges. The taproot gradually turns brick red as the infection spreads. The diseased tissue may not have a distinct margin, or it may occur in streaks that extend almost to the soil surface, but rarely above it. The infected taproot later becomes brown and cracks lengthwise. The small lateral roots and the end of the taproot usually shrivel and die. Affected plants are somewhat stunted and grow more slowly than healthy plants. Later, a cluster of fibrous roots may form just below the soil surface above the stem decay. Plants may recover if they aren't under stress from other factors such as temperature, moisture, nutrients, or insect pests.

Management: The best means of controlling *Fusarium* root rot is to use long rotations out of legumes. A 6–8 year rotation should be practiced to hold the disease in check and to ensure that a profitable crop can be grown. Plant early on well-drained, well-fertilized soil. During the season, cultivate shallowly to avoid injuring roots. Cultivation should cease if root rot appears unless the soil is packed so hard that plants have difficulty growing. Resistant or tolerant varieties are available and should be planted to help manage the disease. Refer to Extension publication *Disease-Resistant Vegetables* (A3110) for a listing of resistant cultivars.

Bacterial brown spot

Description: Bacterial brown spot is the most commonly observed bacterial disease of beans in Wisconsin. The disease rarely kills the affected plant, but severe infections may defoliate it and lower yields.

Disease cycle: The bacteria overwinter in plant debris or on the seed. The disease is particularly troublesome in cool, humid years when there is a lot of rainfall. The organism enters the plant through natural openings such as leaf pores or stomata. New lesions appear 3–5 days after infection.

Symptoms: Small, water-soaked areas appear on infected leaves. As these small lesions develop, the centers become dry and fall out, giving the leaves a tattered appearance. Similar lesions may develop on the pods.

Management: Bacterial brown spot can be prevented by practicing a 3-year rotation and plowing under debris in the fall to reduce the amount of inoculum in the soil. In addition, it is important to use disease-free seed. Foliar applications of copper compounds or the copper salts of fatty acids may provide some control in light infections.

Halo blight

Description: Halo blight is another bacterial disease of snap beans. Like brown spot, it is transmitted through the seed and can cause serious losses in fields where diseased seeds are planted.

Disease cycle: The bacteria overwinter in diseased vines and on the seed. Because the bacterium is so infectious, only one infected seed in several thousand is sufficient to cause a severe infection. Usually the bacteria are spread by wind, rain, dust, tools, equipment, animals, and humans.

Symptoms: The first symptoms of halo blight are small, angular, water-soaked spots ⅛–¼ inch in diameter on the lower leaf surface. As the disease progresses, these lesions enlarge and grow together. Later, a halo-like cone of greenish-yellow tissue about 1 inch in diameter develops outside the water-soaked area. This halo helps to distinguish halo blight from common blight. Additionally, infected leaves may be yellow, malformed, and crinkled. The infection will cause the leaves or even the entire plant to wilt and die quickly. Halo blight favors weather that is cool (60–68°F) and humid.

Management: Scout infected fields or areas weekly to determine the level of infection. However, be extremely careful to sanitize equipment before entering another field since the pathogen is easily spread from plant to plant. There are several nonchemical controls that prevent blight. First, plant only certified disease-free seed. Next, use a 3-year rotation that excludes beans, soybeans, and cowpeas to reduce inoculum buildup. Finally, plow under all plant debris immediately after harvest.

Downy mildew

Description: Downy mildew is a common and troublesome fungal disease wherever peas are grown under cool, moist conditions. In most parts of the United States the disease is present during the early part of the growing season and is seldom of economic importance.

Disease cycle: The fungus overwinters in pea straw and as thick-walled oospores mixed with seed and soil. Spores are produced on infected plants and are moved to other plants or fields by splashing rain or running water, wind or equipment. Symptoms appear 6–19 days after infection. Plants can be infected throughout the season.

Symptoms: The symptoms of downy mildew first appear on the lower leaf surface as fluffy, white to gray patches. These patches often turn darker with age. On the upper leaf surface there are yellow to brown areas with indistinct margins. If the growing point of the plant becomes systemically infected, the upper portion of the plant may become distorted and significantly stunted. Such plants may become chlorotic. Young pods are particularly susceptible to infection. Infected pods may have several yellow-brown diseased areas of indefinite size and shape. These irregular blotches may be slightly sunken. On the inside of the pod, there may be a white, felt-like growth. Peas developing near these areas remain small and may have brown, sunken spots.

Management: Downy mildew can be controlled through crop rotation and resistant varieties. A rotation of at least 3 years is necessary to reduce the potential for infection. Several pea cultivars are resistant to downy mildew.

Sclerotinia white mold

Description: Many plants are susceptible to *Sclerotinia* white mold, including nearly all vegetable crops. A few of the species affected include alfalfa, beans, beets, cabbage, cantaloupe, carrots, celery, cucumbers, eggplant, lettuce, onions, potatoes, radishes, and tomatoes. Peas are one of the few crops that are not susceptible.

Disease cycle: The fungal pathogen survives as hard, black sclerotia in the soil. These sclerotia may survive in the soil for 5 or more years. Under suitable conditions, sclerotia within 2 inches of the soil surface produce small cup-like “mushrooms” that release ascospores into the air. Ascospores are capable of infecting susceptible plants. Continuous soil moisture is necessary to activate the overwintering sclerotia in the soil and 48–72 hours of wetness is essential for leaf infection. Only 16–24 hours are required for infection of the stems, leaves, or pods that come into contact with infected blossoms. Therefore, the length of time plants remain wet and the frequency of rainfall or irrigation when the inoculum is available is more important than the amount of water received.

Symptoms: Infection is most common after blossoming begins. On beans, blossoms are usually the plant part first colonized by the fungus. The infection spreads to stems, leaves, and pods that come into contact with colonized blossoms if sufficient moisture is present. Irregularly shaped water-soaked spots on these plant parts enlarge and a soft watery decay soon follows. This “watery soft rot” is followed within 1–3 days by a white moldy growth. The white “cottony” growth can spread rapidly if given warm, moist conditions and can kill a plant in 4–10 days.

Management: It is essential to use disease-free seeds. Crop rotation with nonhost crops, such as cereals and corn, may reduce disease by reducing initial inoculum. However, inoculum may be maintained on weeds or may be carried into the field by wind, irrigation water, or insects. In areas prone to disease, avoid excessive irrigation before and during the bloom period. Timely harvest, followed by rapid cooling and storage can provide simple and effective control of white mold.

Because of the wide host range of the fungus and the fact that the disease organism can remain in the soil for more than 5 years, it is often difficult to control the disease once it becomes established. Several fungicides control the disease; refer to Extension publication *Commercial Vegetable Production in Wisconsin* (A3422) for specific fungicide information.

Viruses

Several virus diseases affect legumes. All viruses are transmitted from diseased plants to healthy plants by aphid feeding. Therefore, it is important to control aphid populations early and control weeds that may harbor high numbers of aphids. Some snap and wax bean cultivars as well as many pea cultivars are disease resistant. Once a plant becomes infected with a virus, there is no cure. The most common virus affecting both peas and beans in Wisconsin is the bean yellow mosaic virus. This virus has a wide host range including many legumes. Symptoms appear as a yellow mottling of the leaves. The yellowed areas enlarge until the entire plant takes on a yellowish cast. The leaflets curl downward at the margins and droop at the point where they are attached to the petiole. Plants that are infected when young become stunted.

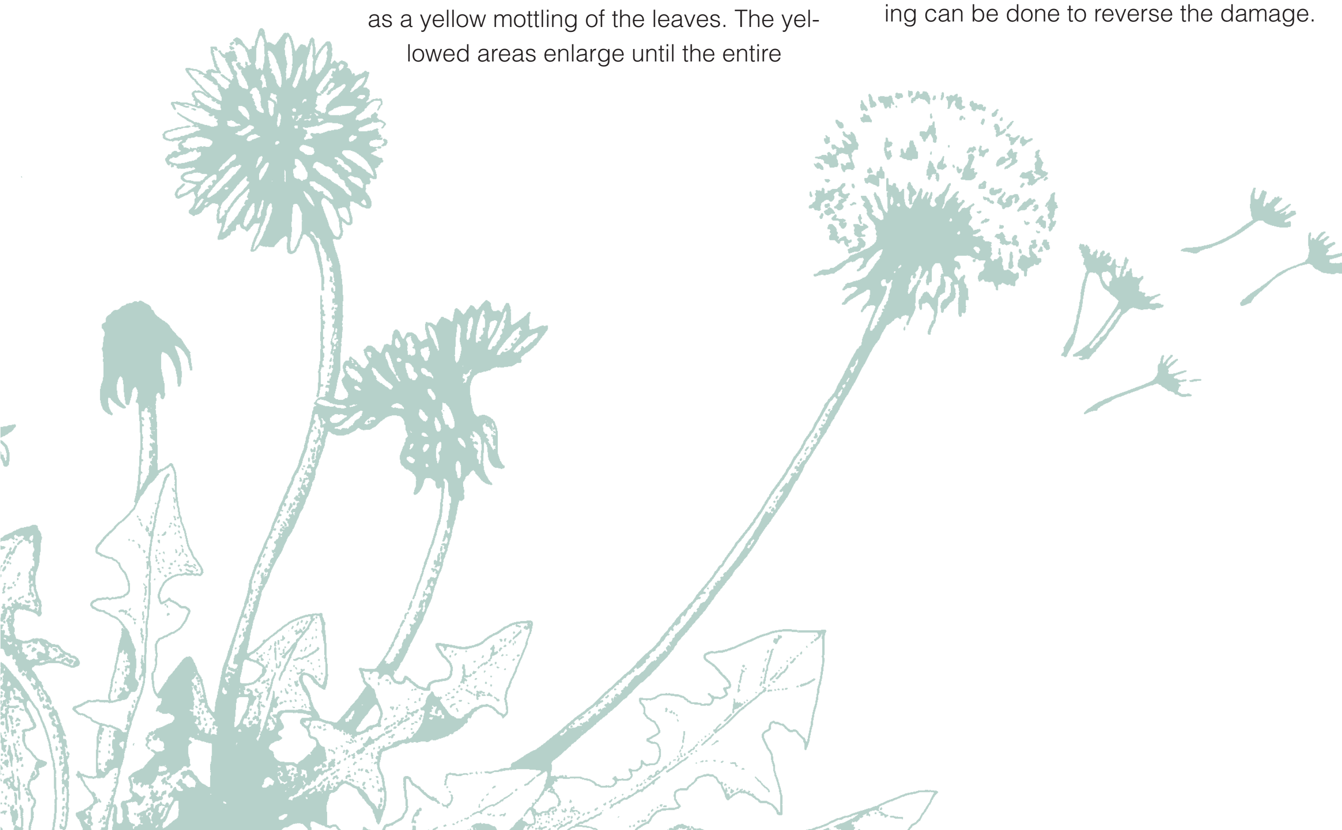
Environmental disorders

Bronzing

Bronzing is caused by high levels of atmospheric ozone pollutants. It causes the leaves of beans to become bronze in color. Typically this disorder will not affect yield.

Sunscald

Sunscald can affect all above-ground parts of older plants. It typically occurs when periods of intense sunlight and low humidity follow periods of high humidity, warm temperatures, and cloudy weather. Snap, lima, wax, and dry beans are all susceptible to sunscald; peas are not susceptible. Symptoms begin on the leaf as a slight browning or bronzing of the leaf surface in small patches between the leaf veins. As the problem progresses, the brown areas enlarge and become dry. Once sunscald has occurred, nothing can be done to reverse the damage.



Weed management

Weed management in legumes is essential for plants to produce maximum yields. Weeds compete with crop plants for sunlight, water, nutrients, and space. Before planting, reduce perennial weed populations by smothering with a cover crop (such as buckwheat), by solarization with black plastic, by hand removal, or by using herbicide sprays. Cultivate or hoe regularly to control annual weeds.

Beans quickly form a complete canopy. Once the crop canopy shades the soil surface, weed seeds will not receive adequate sunlight to germinate. Shortly after pea emergence, the fields can be mechanically cultivated to destroy seedling weeds. An early cultivation to destroy germinating weed seedlings will reduce populations of weeds below an economic threshold. Extension publication *Commercial Vegetable Production in Wisconsin* (A3422) lists specific herbicide recommendations.

Additional reading

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