Spinach Production Under Midwest Growing Conditions

Spinach (*Spinacia oleracea*) is a cool-season leafy green that belongs to the Chenopodiaceae family, along with Swiss chard and beets. Native to Asia, spinach has been cultivated for over 2,000 years. Known for its nutritional benefits, popularized by the Popeye the Sailor Man cartoon in the United States, spinach is grown for both fresh market and processing. The United States is the second largest producer of spinach in the world, annually harvesting 960,600 pounds of spinach from 62,850 acres with a value of over $529 million.

Cultivars

Spinach cultivars normally are categorized as savoy, semi-savoy, or smooth. Savoy and semi-savoy refer to the amount of wrinkling of the leaves. Smooth varieties are normally grown for processing, such as freezing and canning, as these are quicker growing and higher yielding. Savoy types most often are grown for fresh market and in-home gardens, because these have a longer shelf life, greater bag fill, and sweeter taste. Semi-savoy hybrids have gained in popularity and can be produced for both fresh and processing markets.

When choosing a spinach cultivar, growers should pay close attention to the season in which the spinach will be produced. Specific cultivars have been developed for early spring and fall, summer, or overwinter production. As early spring and fall provide the most ideal conditions for spinach growth, most varieties perform well, including the most common open-pollinated cultivar, Bloomsdale. Cultivars developed for summer cultivation are slower bolting and include Indian Summer, Olympia, and Aztec. Spinach cultivars grown for overwinter high tunnel production generally have a more upright growth habit for ease of harvesting. Popular varieties for winter high tunnel production include Auroch, Regiment, Giant Winter, Gazelle, and Space.

A study conducted at the Iowa State University Horticulture Research Station evaluated spinach cultivars for spring production in the upper Midwest. Table 1 provides information on the cultivars evaluated and their characteristics. For photos of each cultivar, refer to Figure 1.

Table 1. Spinach cultivars evaluated at the Iowa State University Horticulture Research Station, Ames, Iowa

Cultivar	Leaf Type	Characteristics
Acadia	Semi-savoy	Upright plant with short stem. Oval leaves with semi-pointed end. Slower bolting in late spring/early summer.
Apache	Smooth	Upright growth habit. Pointed leaves with compact growth. Best for spring and fall production.
Aztec	Semi-savoy	Less upright plant with long stems and dark green, pointed leaves. Very heat tolerant.
Kolibri	Savoy	Oval leaf with medium stem length and compact growth. Good for all season production.
Red Tabby	Savoy	Red-veined, angular leaf shape with large mid-leaf indentation and medium stem length. Less upright growth. Performs well in spring and summer.
Renegade	Smooth	Rounded leaf with lighter green color. Semi-upright growth. Bolt resistant.
Seaside	Semi-savoy	Small, round leaf with short stems good for long baby leaf harvest window. Slow to bolt in spring and summer.
Space	Smooth	Round leaf with compact growth and short stem. Lighter green colored leaves. Good for all seasons.
Verdil	Smooth	Light green, very pointed, large leaves. Vigorous but more sensitive to heat than other varieties trialed.

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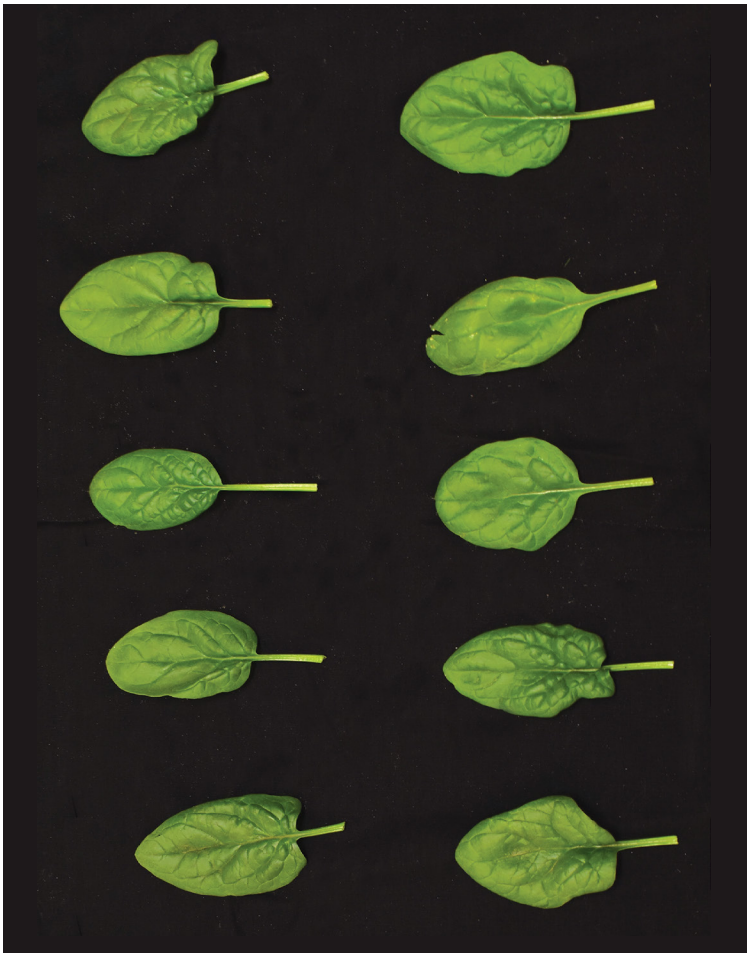
Figure 1.

Acadia

Apache



Aztec

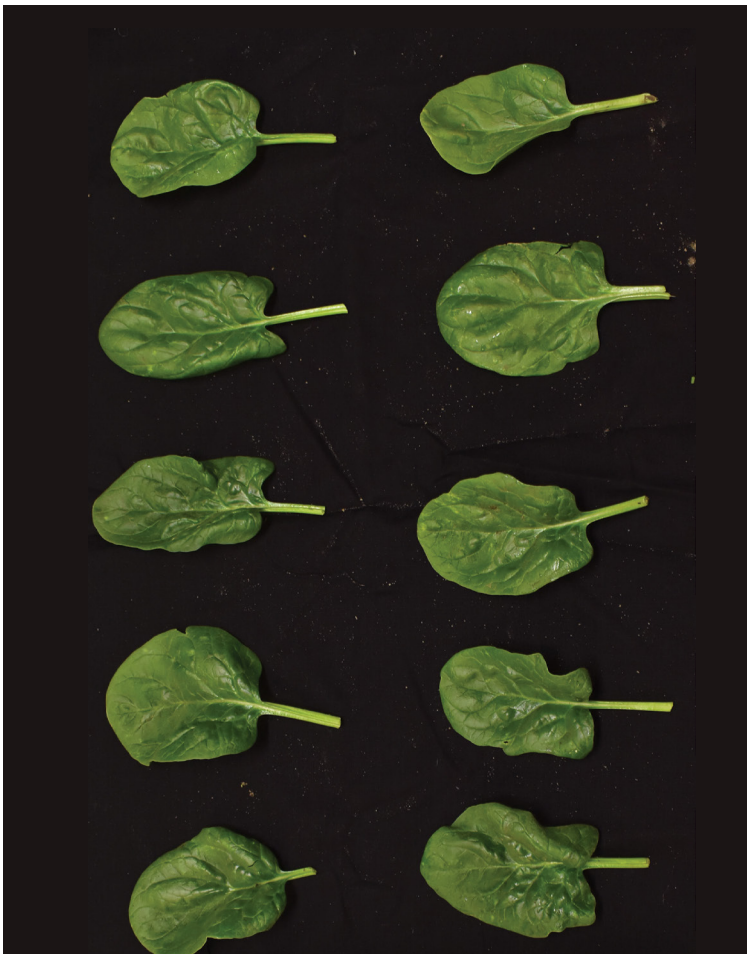
Kolibri

Red Tabby

Renegade

Seaside

Space



Verdil

Site selection and planting

Spinach prefers fertile, well-drained, sandy loam soils with a pH of 6.0 to 7.5. Spinach is sensitive to basic soils and leaves may display manganese deficiency in higher pH soils. Spinach seeds germinate best in cool soils, with a soil temperature between 45°F to 68°F. High soil temperatures decrease germination and should be avoided with germination inhibited at 84°F. For direct seeding, sowing can begin about four to eight weeks before the average last frost date in the spring, or as soon as the soil can be worked. For fall and winter production, sowing should occur six to eight weeks before the average first frost, mid-August in Iowa.

Direct seeding is the most common form of establishment for spinach production. Use of a precision seeder, such as the Jang seeder or Johnny's Six-Row Seeder, is recommended. Prepare the ground well to ensure a fine seedbed before sowing. For baby leaf production, rows can be as close as two inches with 3 to 5 seeds per inch within a row. For full size and bunching spinach, rows should be 12 to 18 inches apart with 2 to 6 inches spacing between plants in row. Seeds should be placed one-half inch deep.

Transplanting spinach is an option for summer production when soil temperatures exceed the optimum germination range. Sow seeds in 128-cell flats four to five weeks before transplanting. One week prior to transplanting, harden plants off in a protected, outside area.

For winter high tunnel production, seed spinach in mid-August to ensure adequate growth before freezing temperatures slow plant growth. If the soil temperature is too high in the high tunnel, transplanting is recommended.

Optimum spinach growth occurs between 60°F and 75°F. Summer production in Iowa is not recommended as increasing daylength and temperatures exceeding 85°F cause plants to bolt. Spinach plants are cold tolerant and will survive temperatures as low as 0°F, but growth ceases when temperatures fall below 36°F. In winter high tunnel production, spinach plants will continue to grow when temperatures are raised using secondary row covers. Row covers are made of fabric or cloth of varying thickness and protect the crop like a blanket. Row covers should be applied over wire hoops placed in the ground 2 or 3 feet apart to protect the plants from contact with frozen material. Temperatures under the row cover should be monitored to ensure they do not exceed optimum levels, as can occur on sunny days in winter, and ventilated as necessary.

Fertilization

It is important to perform a soil test prior to planting spinach to avoid nutrient imbalances and maintain a soil pH between 6.0 and 7.0. Spinach is a shallow rooted, heavy feeder that requires high amounts of nutrients. If using compost, ensure it is well done, mature, and free of pathogens and weed seeds. Although compost increases organic matter and provides some nutrients, additional fertilizer will be required to meet spinach nutrient demands. Table 2 provides recommended fertilizer application rates based on soil test analysis. Nitrogen can be applied in split applications. Apply half of the recommended rate pre-plant and remaining during the growing period. Entire recommended phosphorus and potassium can be applied at pre-plant.

Table 2. Fertilizer recommendation for commercial spinach production

Nutrient concentration(s) from soil test	Fertilizer needed, pounds per acre	
Phosphorus, ppm	**Phosphate, P_2O_5**	**Status**
Less than or equal to 15	75-100	Low
16-30	50-75	Medium
31-50	40-50	High
51 and higher	0	Very High
Potassium, ppm	**Potash (K_2O)**	
Less than or equal to 80	120-150	Low
81-140	100-120	Medium
141-200	50-75	High
201 and higher	0	Very High
Organic matter, percentage		
Less than or equal to 3%	80-100	Low
3.1-19.0	60-80	Medium
19.1 and higher	40-60	High

Irrigation

One to one-and-a-half inches of water should be applied to the crop weekly. Drip irrigation is recommended to reduce disease issues and keep leaves clean. It also allows the grower to provide fertility directly to the crop by injecting it directly through the irrigation system. Overhead irrigation can cause soil to splash onto the leaves, increasing washing time. Increased leaf-wetness from overhead irrigation also increases the incidence of downy mildew and spread. If overhead watering is necessary, water the spinach plants in the morning to allow the leaves to dry during the day. It is best to water spinach a few times a week, instead of one long soak. Inadequate moisture levels will cause spinach to bolt. In winter high tunnel production, water less frequently, but ensure an adequate moisture level is maintained.

Weed management

Spinach is a poor competitor with weeds; therefore, beds should be kept clean. Performing stale seed bed techniques prior to sowing can decrease weed pressure as spinach is established. Hand weeding and regular cultivation are required to maintain a weed-free growing area. Below are a few recommended herbicides for weed management in spinach. Follow label instructions for application rate, crop stage, method of application, re-entry, post-harvest interval, and safe handling of products.

Postemergent broadleaves:
Carfentrazone (Aim®)
Phenmedipham (Spin-Aid®)
Clopyralid (Stinger®)

Postemergent grasses:
Sethoxydim (Poast®)
Pelargonic acid (Scythe®)

Insect pests

The major insect pests of spinach are aphids, beet armyworms, cabbage loopers, flea beetles, and spinach leaf miners.

Aphids

Green peach aphids, light green or pink in color, may cause significant damage to spinach plants. Aphid infestation can cause leaf distortion and curling, resulting in unmarketability and potential death of the plant. As aphids feed on spinach leaves, they excrete phloem sap ("honeydew"), providing an ideal habitat for sooty mold infection and transmitting other diseases. High rates of nitrogen fertilizer may increase aphid populations. Aphid infestations normally begin on field edges, often harbored in weeds, and occur in a cluster of infected plants. Regular monitoring should be performed as aphid populations increase rapidly and may be difficult to control. Control measures should be used against aphids when the threshold of two aphids per seedling or seven aphids per mature plant is reached. Treatments should be used sparingly and less harmful organically approved products, such as neem oil and insecticidal soaps, are preferred. Other organic insecticides include: pyrethrin (Pyganic®) and potassium salt of fatty acid (M-Pede®). Many parasitic insects of aphids, such as ladybugs, are harmed by conventional insecticides. Effective conventional insecticides include: imidacloprid (Admire Pro®), acetamiprid (Assail®), clothianidin (Belay®), flonicamid (Beleaf®), malathion spidotetramat (Movento®), thiamethoxam (Platinum®), flupyradifurone (Sivanto®), tolfenpyrad (Torac®), and afidopyropen (Versys Inscalis®).

Beet armyworms

The larval stage of beet armyworms (*Spodoptera exigua*) feed in groups, and can cause significant damage, even eating entire leaves. Armyworm moths lay eggs in clusters near the base of the plant. Egg clusters are covered in white, cotton-like scales and become dark in color before hatching. The caterpillars are gray to brown with a black stripe on either side of the body and black spots on the back. Beet armyworms emerge in the spring, feeding at the soil surface, before pupating into moths and laying eggs for subsequent generations. Regular scouting should be performed for the characteristic cottony egg clusters. Maintaining a weed-free field, especially of lamb's quarters and wild mustard, can decrease beet armyworm infection by limiting additional food sources. Using available insecticide sprays limit infection, especially when used to control young armyworms.

For organic spinach production, *Bacillus thuringiensis* (Bt) products and Pyrethrin (Pyganic EC 5.0 II®) are effective. Effective conventional insecticides include: indoxacarb (Avaunt®), bifenthrin (Brigade 2EC®), tebufenozide (Confirm 2F®), chlorantraniliprole (Coragen®), spinosad (Entrust SC®), cyantraniliprole (Exirel®), methoxyfenozide (Intrepid 2F®), methomyl (Lannate LV®), zeta-cypermethrin (Mustang Maxx®), permethrin (Perm-Up 25DF®), spinetoram (Radiant 1SC®), and carbaryl (Sevin XLR Plus®).

Cabbage loopers

Cabbage loopers can cause extensive damage to spinach leaves, chewing holes in leaves of all stages, resulting in unmarketability. If populations reach high levels, loopers may migrate to spinach crowns and kill the plant or stunt growth. Cabbage loopers have many alternative hosts, including members of the brassica family. Loopers are the larval stage of moths with mottled gray-brown wings. The loopers are light green in color and move by arching their back in a 'looping' motion. Spinach plants should be monitored regularly, scouting for evidence of looper damage or the presence of eggs and active loopers. Spinach should be treated when the threshold of one larva per 50 plants is reached. Effective chemical sprays for conventional and organic production are similar to those used for beet armyworms. Care should be used when using chemical sprays, since parasitic wasps, a beneficial insect known to aid in the control of loopers, may be harmed by their use.

Flea beetles

Many species of small, jumping beetles in the *Coleoptera* order, can affect spinach plants. Flea beetles feed on spinach leaves, making small holes and resulting in unmarketability. Flea beetles lay eggs in the soil and on leaves, and often migrate from other susceptible species grown at the same time as spinach, such as brassica crops. Row covers and other netting materials such as ProtekNet are an effective means of controlling flea beetle attack. Plants should always remain covered other than during harvest. Spinach should be treated when populations reach one flea beetle per 25 plants. Many pesticides are effective at controlling flea beetle populations, including thiamethoxam (Actara®), imidacloprid (Admire Pro®), beta-cyfluthrin (Baythroid XL®), clothianidin (Belay®), zeta-cypermethrin (Mustang Maxx®), thiamethoxam (Platinum 2SC®), carbaryl (Sevin XLR Plus®), and tolfenpyrad (Torac®). Organic producers can use pyrethrins, such as Pyganic EC 5.0 II®, as an alternative control measure.

Leafminer

Spinach leaf miners (*Pegomya hyoscyami Panzer*) overwinter in the soil, hatching in late April or May. The adult flies lay eggs on host leaves and the larva burrow between leaf tissue, resulting in a winding "mine" of yellow tissue. Most often young spinach plants are most susceptible and may grow out of infection, but producers growing spinach for baby leaf production may be economically impacted by a high rate of unmarketable spinach leaves. Scout for eggs on the underside of leaves and treat when observed. Pyrethrin (Pyganic EC 5.0 II®), azadirachtin (Neemix®), and spinosad (Entrust SC®) are effective organic controls. Conventional insecticides include: abamectin (Agri-Mek SC®), clothianidin (Belay®), spirotetramat (Movento®), permethrin (Perm-Up 25DF®), thiamethoxam (Platinum 2SC®), spinetoram (Radiant 1SC®), dinotefuran (Scorpion 35SL®), and cyromazine (Trigard®). Many common weeds, such as lamb's quarters and pigweed, are alternate hosts of leaf miner and should be controlled to prevent infestation. The use of row covers also can be used to prevent infection by limiting the fly's ability to lay eggs.

Diseases

Downy mildew

This disease, also known as blue mold, is caused by the oomycete *Peronospora effuse*. It is the most common disease threatening spinach in the upper Midwest, occurring in cool, humid weather, as is common in the spring and fall. This pathogen can survive in debris and infected seed and spread rapidly by wind dispersal of spores. Sporangia cause infection when they land on spinach leaves with symptoms occurring as early as the cotyledon stage. Dew formation and moisture on the leaves increase the spread of infection. Symptoms appear as a chlorotic lesion on the leaf surface with gray masses of sporangia on the underside of leaves below the lesions. Infection can lead to yellow or black leaves, seedling death, or reduced yield and quality of mature plants. Many downy mildew resistant cultivars of spinach are available, and their use is the most effective means of management. Hot water treatment of seeds can be used to reduce seedborne infection. Infected debris should be incorporated into the soil to encourage breakdown. Crop rotation can help control repeated infections by alternating susceptible hosts. Overhead irrigation is discouraged as the increase in leaf wetness may increase infection. Available fungicides to manage infection include cymoxanil (Curazate 60DF®), fluxapyroxad + pyraclostrobin (Merivon®), oxathipiprolin + mandipropamid (Orondis Ultra Premix®), fluopicolide (Presidio®), cyazofamid (Ranman 400SC®), mandipropamid (Revus®), famoxadone + cymoxanil (Tanos®), flutriafol + azoxystrobin (Topguard EQ®), and ametoctradin + dimethomorph (Zampro®).

White rust

This oomycete pathogen caused by Albugo occidentalis produces small, raised pustules on the underside of spinach leaves with chlorotic areas on the leaf surface. White rust thrives in cool, humid conditions, especially on the wet surface of leaves. Leaf surfaces must remain wet for two to three hours for infection to occur, so performing drip irrigation or using overhead irrigation only under conditions that allow for leaves to dry quickly can reduce infection. Infected leaves are unmarketable, and infection may cause plant death. Use disease-free seed or perform a hot water seed treatment to reduce infection. Rotate crops for three years with non-host species. Cultivars with partial resistance are available, but no completely resistant cultivars exist currently. Effective pesticides include fluxapyroxad + pyraclostrobin (Merivon®), fluopicolide (Presidio®), famoxadone + cymoxanil (Tanos®), and flutriafol + azoxystrobin (Topguard EQ®).

Damping off

This soilborne fungus infects spinach seedlings and is caused by infection of *Pythium* spp. or *Rhizoctonia* in fields with poor drainage. Damping off causes seedling death and can be controlled by eliminating water accumulation or oversaturation of the soil before seedlings emerge. All residues from previous crops should be incorporated and fully broken down before seeding spinach, as high amounts of debris can increase the incidence of damping off.

Harvesting

Spinach can be harvested for baby leaf production and full-size leaves and offer an opportunity for multiple harvests. The USDA designates small (or baby) leaves as measuring up to 3.5 inches from the leaf tip to the petiole base. Direct seeded spinach for baby leaf production will reach maturity in three to five weeks, depending on the time of year and environmental conditions. A second cut is possible in approximately four to six weeks. Full-size spinach leaves can be bunched or sold loose, often measuring at least five inches in length from leaf tip to petiole base.

Spinach leaves can be harvested individually when they reach the desired size, leaving the center leaves to continue growing. This method is preferred when growing full-size leaves and in winter high tunnel production, as plants need larger reserves to regrow during winter conditions. To harvest whole beds of spinach for baby leaf production and still allow for re-growth, cut whole plants above the growth point, leaving about 1 to 2 inches above the soil line. Spinach can be harvested in this manner with a knife or using the Quick Cut Greens Harvester, a baby greens harvest tool powered by an electric drill. For more information on using the Quick Cut Greens Harvester for spinach see this video from Iowa State University Extension and Outreach: extension.iastate.edu/vegetablelab/leafy-greens-quick-cut-greens-harvester. Harvest can be continued throughout the spring until temperatures reach over 80˚F and spinach plants begin to bolt, usually by mid-June in Iowa. Bolting causes the spinach leaves to become bitter and reduces the size of marketable leaves.

Yellowing, damaged, or diseased leaves should be removed. Spinach should be washed thoroughly before packaging or selling, removing any dirt and debris. Washed spinach can be stored at 32˚F and 95% humidity for 10 to 14 days. Package loose leaves in a clamshell container or plastic bag. Spinach leaves also can be mixed with other baby greens in a salad mix.

Results of spinach cultivars evaluated at Iowa State University Horticulture Research Station, Table 2, can provide information on potential yield and average leaf weight. Marketable yields represent a 1 sq. ft. harvested area.

Table 3. Marketable spinach yield of spinach cultivars at Iowa State University Horticulture Research Station from the 2021 growing season.

Cultivar	Marketable leaves (g)/ft²	Average leaf weight (g)
Acadia	138.8	2.0
Apache	84.6	1.7
Aztec	145.6	1.5
Kolibri	117.1	2.5
Red Tabby	90.3	1.7
Renegade	124.5	2.3
Seaside	71.2	2.1
Space	89.4	2.1
Verdil	138.8	2.1

Authors

Anne Carey, graduate research assistant, Department of Horticulture–Iowa State University

Ajay Nair, extension vegetable production specialist and associate professor, Department of Horticulture–Iowa State University

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